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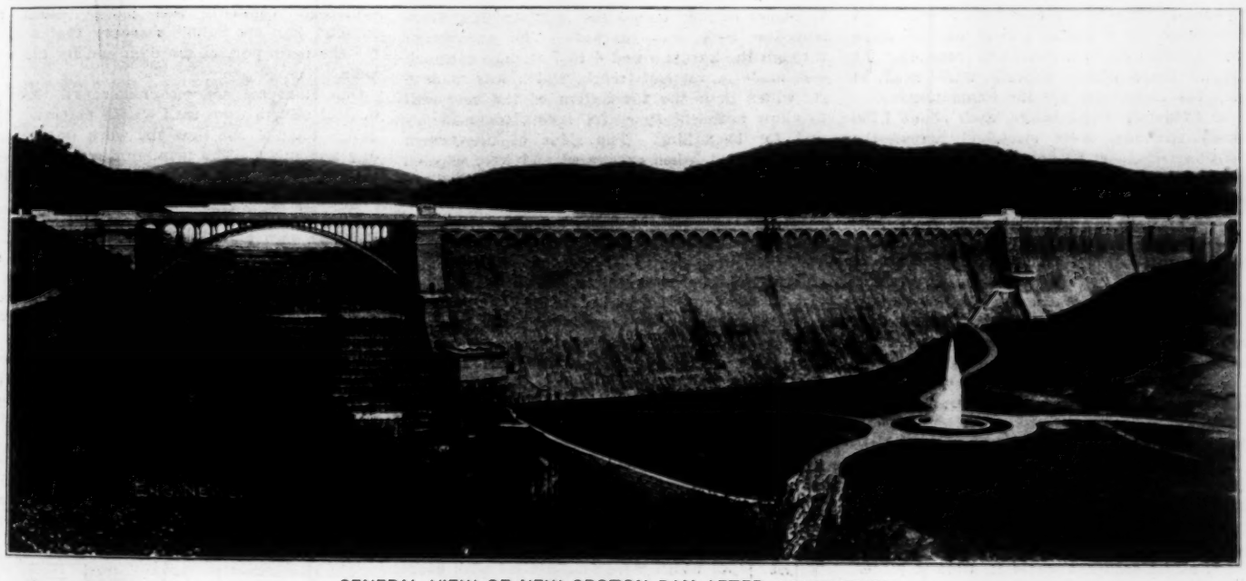
THE NEW CROTON DAM.

By Edward Wegmann,* M. Am. Soc. C. E.

The New Croton Dam is located about 3¼ miles below the Old Croton Dam (built 1837-1842), and forms a storage reservoir of about 30,000,000,000 gals. capacity for the water supply of the City of New York. The work was begun on Sept. 20, 1892, and was practically finished by Jan. 17, 1906, with the exception of an iron railing which is now being erected on top of the dam. In previous numbers of the Engineering News† the contract plans were described, the changes made in these plans during the construction were mentioned, and some account was given of the progress of the work. As the articles about this important dam, thus far the highest structure of its kind, are scattered in 13 volumes of the Engineering News, a short account of the construction of the dam will be given here with details that are of interest for engineers and contractors. Engraving on this page and Figs. 2 and 4 give a good general idea of the structure, while Fig. 3 shows the



GENERAL VIEW OF NEW CROTON DAM AFTER COMPLETION.

to the original plans, the work was to consist of three parts: (1) A waste-weir about 1,000 ft. long, to be built along the rocky side hill forming the north slope of the valley; (2) a masonry dam about 600 ft. long, extending from the waste-weir across the valley and well into the south slope; (3) an earth dam with masonry core-wall, about 600 ft. long, forming a continuation of the masonry dam to the south side of the valley. The waste-weir was to be curved at its down-stream end to join the masonry dam and at its up-stream end so as to terminate in the hillside. A waste-channel was to be excavated in rock between the waste-weir and the north hillside. It was to be 125 ft. wide at the junction of the waste-weir with the masonry dam and 50 ft. wide at its up-stream end. The masonry dam, waste-weir and core-wall were to be founded on rock. A large masonry wing wall was to be built on the down-stream side at the junction of the masonry dam and the earth dam. The top of the dam was to serve as a highway, which was to be carried across the waste-channel by means of an arched bridge of 200-ft. span.

On Sept. 16, 1896, the Aqueduct Commissioners, under whose direction the dam was built, decided to extend the masonry dam 110 ft. to the south and to reduce the length of the earth dam by the same distance. This change reduced the maximum height of the earth dam from 120 to 50 ft. The discovery of some cracks in the core-wall of the earth dam, which was to have a maximum height of 175 ft., gave rise to some doubts about the safety of this part of the dam. On June 21, 1901, the Aqueduct Commissioners appointed a board of engineers (J. J. R. Croes, Edwin F. Smith and Elnathan Sweet, members of the American Society of Civil Engineers) to examine the plans for the construction of the dam and the work of construction, as far as the same had proceeded, and to report to the Aqueduct Commissioners what changes, if any, should be made in the plans for the construction of the dam. On Nov. 18, 1901, the board of engineers handed down its report, in which it recommended that practically the whole earth dam should be replaced by a masonry dam similar to the one already built, in order to make the dam absolutely secure against disaster. This recommendation was adopted by the Aqueduct Commissioners on April 16, 1902, and the earth dam was replaced by a masonry structure, with the exception of a short piece 145 ft. long from a gatehouse built at the point where the Old Croton Aqueduct crosses the dam, to the southerly end of the dam. The maximum height of this earth bank is only 26 ft.

According to the contract plans the different parts of the dam were to be finished at the following elevations, which refer to Croton Datum, i. e., mean tide at the mouth of the Croton River: Top of waste-weir, Elev. 196; top of masonry dam, Elev. 210, and top of earth dam, Elev. 220. On Oct. 16, 1900, the Aqueduct Commissioners decided to finish the whole dam at Elev. 216, and the waste-weir at Elev. 200, with the exception of a depressed part 250 ft. long, at the junction with the masonry dam, which was to have its crest at Elev. 196.

PROTECTION WORKS.—Before the excavation for the foundation of the dam was begun, the river was turned into a channel 125 ft. wide and some 1,600 ft. long, about 600 ft. of which was excavated in rock along the north hillside of the valley. The new channel was able to discharge all the water wasting over the Old Croton Dam until it was obstructed by the construction of the dam. The total cost of the protection works was about $350,000.

EXCAVATION FOR FOUNDATION.—Owing to the great width of the base of the dam (maximum, 266 ft.), the excavation for the foundation had to be made in open trench. In

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†See Engineering News: Oct. 11 and Nov. 15, 1890; June 2, 1892; Oct. 20, 1898; Nov. 23, Dec. 12, Dec. 19 and Dec. 26, 1901; Jan. 2, 9 and 16, 1902; May 14, 1903; June 16, Oct. 6 and Dec. 1, 1904.

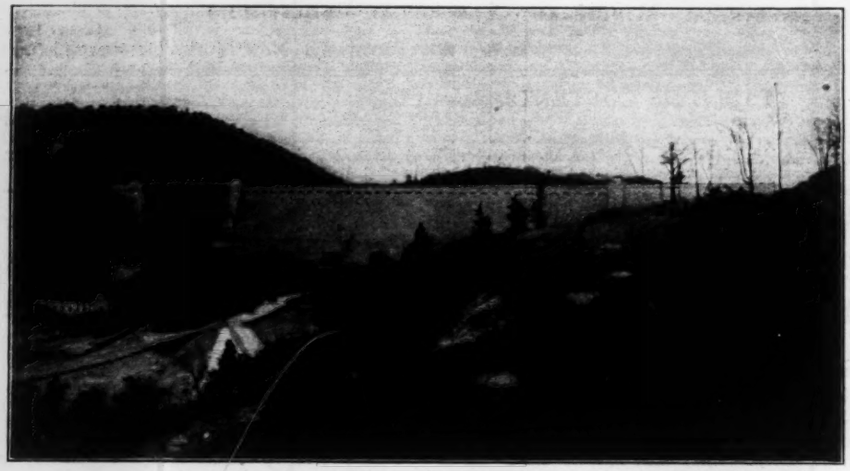


FIG. 2. GENERAL VIEW OF NEW CROTON DAM FROM SOUTH BANK, BEFORE REMOVAL OF CONTRACTOR'S PLANT.

the center of the valley, sand, gravel and boulders had to be excavated to a depth of about 70 to 75 ft. before the bed-rock was uncovered. Towards the south side of the valley the rock was found to be covered by a layer of hardpan, about 120 ft. deep, upon which there was a layer of sand and gravel.

The excavation below the river-bed was made at first with a large dredge having a 2½-cu.-yd. dipper on an 80-ft. boom. This dredge, which excavated about 800 cu. yds. in 10 hours, had to be kept floating in the foundation trench and was replaced by a steam shovel of the same capacity when the bed-rock was reached. At one time three steam shovels were used in making the excavation for the foundation.

Three Lidgerwood cableways, each about 1,200 to 1,600 ft. long, were stretched across the foundation trench 50 ft. apart. They were used in making part of the excavation and, later, in delivering some of the materials required for the masonry. The material excavated was shoveled into skips holding about 3 cu. yds., which were hoisted and transported by means of the cableways. As the excavation assumed larger proportions, the cableways were supplemented by railway inclines, placed at different points on the side slopes and operated by means of stationary hoisting engines and cables. From the inclines the materials excavated were hauled by locomotives on a 36-in. gage track to the spoil banks.

The bed-rock was found to be gneiss on the north side of the valley and limestone in the center and on the south side. The two kinds of rock join each other on a line about parallel with and directly under the old river-bed. At the junction of the gneiss and limestone a layer of black schist occurs, about 4 ft. wide in places, which extends for a short distance below the surface of the rock. Below the schist the gneiss and limestone are joined like one rock. The gneiss rises rapidly with the north hillside, cropping out in places. The limestone extends level across the valley for a distance of about 400 ft. and then rises gradually with the slope of the hillside, being about 25 ft. below the surface at the south end of the dam.

The rock upon which the dam had to be founded varied much in character. The gneiss was much fissured and full of seams. The limestone was found in some places to be sufficiently hard and watertight to answer for the foundation, while in other places it was so soft that it could be excavated with a pick and shovel. There were many seams in the limestone and, in one case, a cave, about 12 × 14 × 20 ft. was discovered under a heavy stratum of solid rock. All the seams in the limestone contained more or less water, which, in some cases, was under heavy pressure. In one instance the water was under a head of 90 ft., requiring a 10-in. pipe to carry it off.

A great many test holes were drilled to explore the seams and the rock was excavated to a sufficient depth to insure a good foundation. The maximum depth to which the rock had to be excavated was about 54 ft.; the average depth was about 20 ft. The greatest depth of the foundation was 131 ft. below the river-bed.

In excavating the foundations for the core-wall, which according to the original plans was to extend about 600 ft. from the masonry dam to the sidehill, 8 to 24 ft. of sand was removed by steam shovels before the hardpan that overlaid the rock was reached. The excavation through the hardpan and 4 to 7 ft. into the rock was made in vertical trench, which was made 6 ft. wider than the foundation of the core-wall to allow sufficient space for laying the masonry and for backfilling. The sides of the trench stood vertical when excavated and were sheeted and braced afterwards, as required.

The total amount of material excavated for the foundations of the dam was about 1,821,400 cu. yds. of earth and 400,250 cu. yds. of rock.

MASONRY.—After solid rock had been reached and all loose and shaky pieces had been removed, the bottom was thoroughly washed by streams of water under heavy pressure and cleaned with brooms. The rock was then "painted" with a grout of neat cement, applied with brushes, which filled up all small cracks or seams. All erosions and open seams were filled with grout, usually made from Portland cement and fine, sharp sand, mixed, either 1 to 1 or 1 to 2, according to whether the grout had to be pumped or poured. Large seams were filled by placing small stones in the grout. Springs that were encountered in the foundation were either drained off to a sump-hole or were confined in vertical pipes which were finally filled with grout or, in a few cases, with clay that was forced by a drop-hammer into the pipes.

The laying of the foundation masonry was begun on May 26, 1896. With the exception of the extension of the main dam (ordered on April 16, 1902, to replace the earth dam), which was built of cyclopean concrete, the dam and the waste-weir were constructed of rubble masonry, faced above the backfilling with ashlar masonry classified as "facing stone masonry." In the bottom foundation courses Portland cement mortar mixed 1 : 2, was used. Above the foundation the masonry was laid in American cement mortar, mixed 1 to 2, except in winter, when Portland cement mortar, mixed 1 : 3, was used.

The ashlar "facing stone masonry" begins at the waste-weir at the rock surface and for the main dam above the refilling, which was brought up to Elev. 70 (i. e., about 23 ft. above the old river-bed). This masonry has a depth of at least 28 ins., and is laid in courses ranging in rise from 30 to 20 ins. The joints do not exceed ½-in. for 4 ins. from the face and not over 2 ins. wide for the remaining depth. The stretchers are 3 to 7 ft. long, and in each [illegible] every third stone is a header, at least 4 ft [illegible]. All joints in the up-stream face of the da[illegible] waste-weir were raked out to a depth of [illegible] and pointed with Portland cement mortar, [illegible] 1 to 1.

The stone used for the greater part of th[illegible] is a dark-colored granite, named "gabro[illegible]" by geologists. It weighs about 185 lbs. p[illegible] ft., and is very hard and tough.

The work of laying the masonry was co[illegible] in winter except in extremely cold weather, [illegible] the thermometer remained steadily belo[illegible] freezing point. In laying masonry in [illegible] weather salt was added to the cement, the [illegible] was heated in large boxes, provided with [illegible] coils, and warm water was used in mixi[illegible] mortar. On cold nights the fresh work [illegible] covered with canvas and in the morni[illegible] surfaces and joints of the work were thoro[illegible] cleaned with steam and hot brine.

The maximum force employed on the work, including the quarry, was 851 men (475 on the dam and 376 in the quarry). The best month's work in the foundation was in June, 1898, when 17,186 cu. yds. of masonry was laid.

The description given above applies to the masonry laid in the dam and waste-weir according to the original plans. The extension of the dam, which was ordered to be made to replace the earthen dam, was built of cyclopean concrete, faced above the backfilling with "facing stone masonry" like the rest of the dam. The cyclopean concrete consists of large quarry stones, bedded in concrete mixed rather wet in the proportion of 1 : 2 : 4, the spaces between the large stones being, also, filled with concrete. About half the bulk of this masonry is concrete. The cyclopean concrete was placed much more rapidly than the rubble masonry that was used for the main part of the dam and for the waste-weir.

One Ransome concrete mixer and three 4-ft. cubical mixers were used on the extension of the dam. Part of the time the work was continued day and night. The maximum amount of cyclopean concrete laid per month was about 16,000 cu. yds., in August, 1904.

In order to avoid the delay caused by shifting derricks, two platforms were erected within the limits of the masonry on the axis of the dam. [See Eng. News, Oct. 6, 1904.] The platforms were 55 ft. apart. Each platform was supported by six steel columns, about 50 ft. high, which were securely anchored to the masonry and braced. The tops of the columns were joined by I-beams, which were covered with 3-in. planks so as to form a platform 25 × 50 ft., the longer dimension being parallel with the axis of the dam. Four derricks were placed on each platform and kept in use until the masonry reached the level of the platform, viz., Elev. 130 (i. e., 86 ft. below the top of the dam). As the masonry was carried up, the braces and finally the wood-

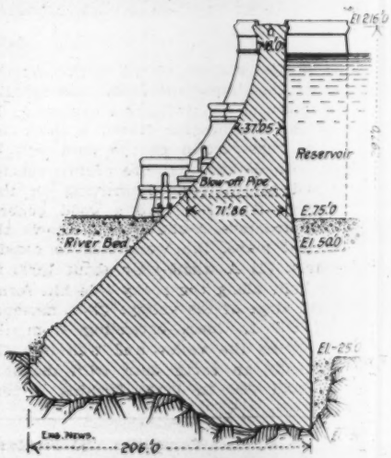


Fig. 3. Maximum Cross-Section of New [illegible]oton Dam.

FIG. 4. LOOKING ACROSS THE TOP OF THE NEW CROTON DAM, FROM THE SPILLWAY END.

work of the platforms were removed, but the columns were left in the masonry. After the masonry had reached the top of the platforms, a trestle work was built against the down-stream face to support a platform for the derricks and the building materials. Additional trestle bents were added as the work was carried up.

THE WASTE-WEIR.—The steps on the down-stream side of the waste-weir were built of "block stone masonry," having a uniform rise of 2 ft. and sufficient depth to bond under the next step above.

The upper two steps of the waste-weir were coped with large blocks of granite dimension stone, and having the exposed surfaces rough pointed. Each of these coping stones was securely anchored to the masonry by means of two 1¾-in. twisted Ransome bars, 3½ ft. long, which were placed in 2-in. holes, drilled in the coping and masonry and leaded.

The ornamental masonry used for the cornice, the parapets at the buttresses, arches for stairway, etc., were built of granite dimension stone.

Two gatehouses were constructed in connection with the dam for controlling the flow from the reservoir. The first, known as Gatehouse No. 1, is built on the down-stream face of the dam near its south end. It regulates the flow into the Old Croton Aqueduct, which crosses the dam at this place. The substructure of the gatehouse, which is 55¼ ft. high, contains four water-chambers. The Old Croton Aqueduct, the flow into which is controlled at the New Croton gatehouse, constructed about three miles above the New Croton Dam, is connected by a brick conduit, 360 ft. long, with the southeast chamber. The water flows from this chamber through two sluiceways, each controlled at each end by a 2½ × 6-ft. sluice-gate, into the southwest chamber, which is connected by a masonry conduit, 510 ft. long, with the Old Croton Aqueduct below the dam. Water can be drawn at the dam into the northeast chamber of Gatehouse No. 1 through a bottom, middle or a surface inlet, as may be desired. These inlets consist of masonry conduits respectively 510 ft., 410 ft. and 22 ft long, having an oval cross-section, 6 ft. wide by 10 ft. high on the inside, with an area equal to that of a circle 7¾ ft. in diameter. The inlets can be closed at the gatehouse by timber drop-gates for which iron grooves are provided in the inlet openings at the gatehouse. The northeast chamber is connected by two sluiceways, each controlled at each end by a 2½ × 6-ft. sluice-gate, with the southeast chamber. It is also connected by an oval passage, 10 ft. high by 6 ft. wide, with the northwest chamber, from which the water can pass through two sluiceways, each controlled at each end by a 2½ × 6-ft. sluice-gate, into the southwest chamber. The oval passage between the northeast and the northwest chambers can be closed by timber drop-gates. An outlet, controlled by two 2 × 8-ft. sluice-gates is constructed at the northwest corner of the gatehouse, which can be connected in the future with a screen-chamber and, then, either with the Old Croton Aqueduct or some new conduit for New York. Iron pipes, 12 ins. in diameter, are placed beneath the floor of the substructure for draining the different water chambers whenever it may be necessary for repairs or inspection. The different sluice-gates of the gatehouse are operated in a vault, constructed beneath the level of the roadway on top of the dam.

Gatehouse No. 2 was constructed on the up-stream face of the dam at the junction of the masonry dam with the overflow-weir to control the flow through three 48-in. blow-off pipes, which are laid in the masonry of the dam at about Elev. 92. The flow into each of these pipes is regulated in the following manner. An inlet opening 4 ft. wide and 52½ ft. high is constructed in the up-stream face of the gatehouse. Its width is reduced in 2¼ ft. to 3 ft. The inlet connects with a chamber 3 ft. wide by 6½ ft. long extending to the floor of the gatehouse (Elev. 207). Two sets of 6 × 6-in. grooves are cut in the sides of this chamber, the up-stream set being used for iron screens, while the down-stream set serves to guide a wooden drop-gate which controls the flow of water from the chamber just described into a sluiceway, 3 ft. wide, 6 ft. high and 8 ft. long, which leads to a second chamber extending to the floor of the gatehouse. For 4 ft. this chamber has a width of 7 ft. and for 2 ft., at its down-stream end, the width is reduced to 3 ft. Grooves are provided in the sides of this chamber, at its down-stream end, for a sluice-gate 3 ft. wide by 6 ft. high, which is operated from the floor of the gatehouse and controls the flow into a second sluiceway, 3 ft. wide, 6 ft. high and 8 ft. long.

The sluiceway last described leads to a circular well 12 ft. in diameter, constructed in the masonry of the gatehouse with its bottom at Elev. 99.25. The masonry lining of the well is corbeled beginning at Elev. 196, so as to terminate into the well at the floor of the gatehouse with a rectangular opening 7½ × 12 ft. in section. At the bottom of the well a 48-in. elbow is embedded in the masonry and is connected with one of the blow-off pipes. The inlet into the elbow is controlled by a cylindrical balanced valve having a conical seat. This valve is placed in a tight cast-iron casing, which has eight ports through which water can flow into the blow-off pipe when the valve is raised, which is done by means of a stem extending through the casing to the floor of the gatehouse, where the hoisting machinery is placed. Each blow-off pipe has, also, a stop-cock which is placed in a vault on the down-stream side of the dam. A 12-in. by-pass pipe, provided with a stop-cock, is placed at the stop-cock of the blow-off pipe in order to reduce the pressure when this stop-cock is to be opened. On each side of the 48-in. stop-cock a 6-in. blow-off is placed at the bottom of the 48-in. pipe.

A 12-in. iron drain pipe is laid from each of the circular wells in the masonry of the dam to the stop-cock vault, where it is connected with one of the blow-off pipes. This pipe begins at the bottom of the well with an elbow provided with a balanced valve, similar to that of the blow-off valve. From the south drain pipe a 12-in. iron pipe is laid to a fountain, where it is connected to five vertical jet pipes, one of 6 ins. and four of 4 ins. diameter. The basin of the fountain has a diameter of 50 ft. and is connected by a 20-in. overflow and discharge pipe with the Croton River.

While the foundation of the dam was being constructed below the river bed, the Croton River was confined to a new channel 125 ft. wide, constructed along the north hillside, as already described. When the masonry was carried up above the river bed an arched relief opening was constructed in the masonry to permit the river to flow through the dam. The arched opening was constructed at the new river channel at about Elev. 50. It was made 28 ft. wide by 24 ft. high at the up-stream face and 20 ft. wide by 21 ft. high at the down-stream face. The reduction in width and height of the opening was made by four off-sets and the sides were "toothed" so as to bond with the concrete with which the opening was finally filled. After the opening had been filled with concrete, grout was forced through small pipes, imbedded in the masonry near the top of the opening, to fill any void spaces that might be found in the concrete.

Two 48-in. scour pipes were imbedded in the concrete at the bottom of the relief opening. The flow into each of these pipes is controlled on the up-stream face of the dam by a 2½ × 5-ft.

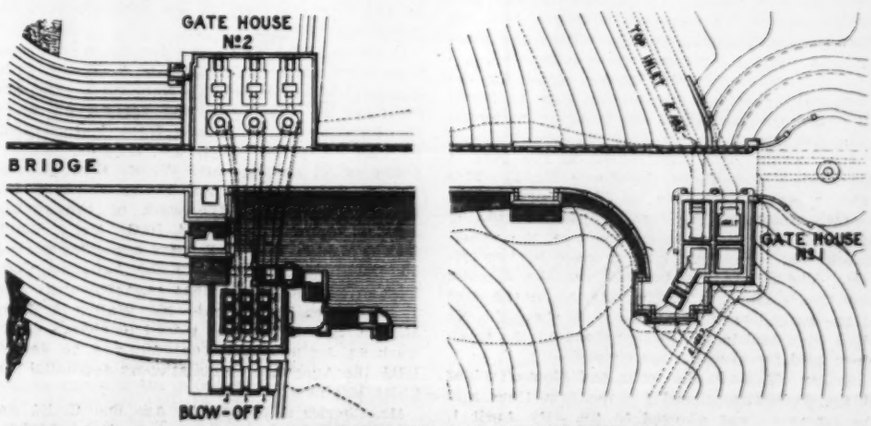


FIG. 5. PLAN OF GATE HOUSES, NEW CROTON DAM.

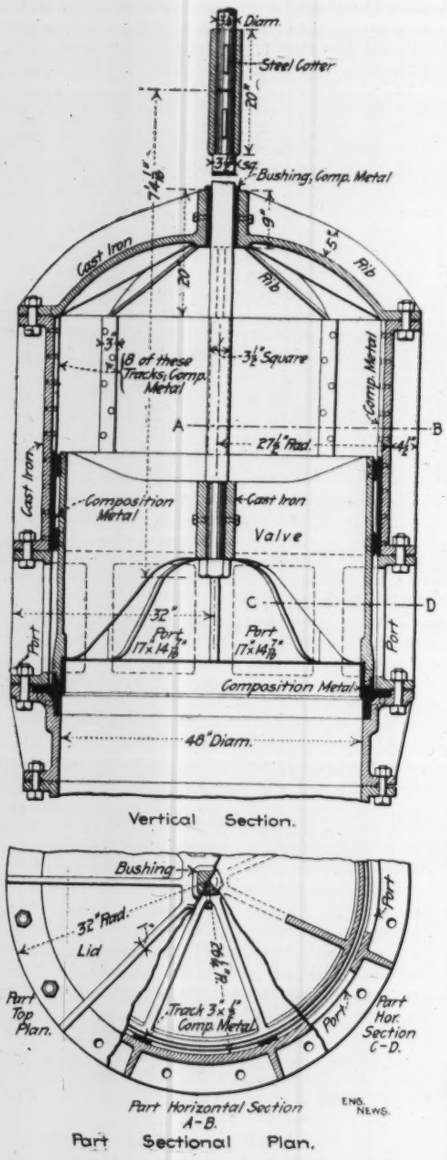


Fig. 6. Balanced Valve in Gate House No. 2, New Croton Dam.

sluice-gate, which is operated by hoisting machinery placed on a small platform constructed at Elev. 153, which can be reached from the top of the dam by means of a ladder. Ordinarily the platforms are submerged and the scour gates can only be opened when the water surface of the reservoir has been lowered by means of the three blow-off pipes to Elev. 150. Each of the scour pipes is provided at the down-stream face of the dam with a stop-cock having a 4-in. by-pass pipe with a stop-cock to relieve the pressure. A vault is built over these stop-cocks.

In order to provide an ample outlet for the Croton River during floods, and, also, to facilitate the transportation of building materials from one side to the other of the dam a second arched opening was constructed in the dam at Elev. 60, just south of Gatehouse No. 2. This opening was 22 ft. wide by 23 ft. high at the up-stream face of the dam and 18 ft. wide by 21 ft. high at the down-stream face, the reduction in width and height being made by two offsets. The sides were toothed and the opening was finally closed with concrete, as in the case of the arched opening at the river channel. No pipes were laid in the masonry, except the small pipes used for grouting the concrete.

On Jan. 22, 1905, the scour and blow-off pipes of the dam were closed for the first time, and the reservoir was allowed to fill. By April 1, 1905, the water had risen in the reservoir to about Elev. 170. It was not allowed to rise more than a foot or two above this level, as some refilling, etc., remained to be done, and in the following October the water was drawn down to Elev. 55 to permit the contractors to complete their work. The last stone was laid in the dam on Jan. 17, 1906.

A roadway 19 ft. wide, formed of concrete laid in sections 6 ft. wide, was constructed on top of the dam. The front face of the dam was corbeled out near the top, in order to get the width required for the roadway. The drainage from this roadway is discharged by 8-in. vitrified pipes (placed at intervals of 114 ft. on both sides of the roadway and provided by suitable gratings in the gutters) into a 4 × 4-ft. sewer constructed in the masonry of the dam under the roadway. Iron railings are placed on both sides of the roadway, except at the buttresses and pilasters, where stone parapets are built. The railing consists of wrought-iron pipes with cast-iron post caps, bases and special channels. The railing has panels 9½ ft. long between the centers of posts and is 4 ft. high above the masonry base. Each post is anchored by 4-in. bronze bolts to the masonry, the bolt holes being grouted with Portland cement. All ironwork was galvanized and given three coats of paint after being erected.

The roadway is carried across the waste channell by a steel arch bridge of 200-ft. span.

CONTRACTORS' PLANT.—The contract for the New Croton Dam included in addition to the work of the dam the construction of 21 miles of new highways and the repairs and reinforcement of 3 miles of the Old Croton Aqueduct that were to be submerged by the reservoir. The principal items of the plant used by the contractors on this work were:

11 Locomotives for 36-in. gage.
82 Flat cars for 36-in. gage.
200 Dump cars for 36-in. gage.
750 tons of steel rails (30-40 lbs. per yd.).
3 Steam shovels (bucket 1½-2½ cu. yds.).
1 Dredge, 80 ft. boom, 3 cu. yd. bucket.
39 Steam boilers, total capacity 1,400 HP.
15 Steam pumps, total capacity 20,000,000 gals. per day.
51 Hoisting engines.
11 Steam engines, 10-50 HP.
20 Steam drills.
75 Derricks (boom, guy and stiff-leg).
3 Cableways, 1,250 to 1,650 ft. long, with engines, etc.
3 Stone crushing plants.
8 Concrete mixing machines, etc., etc.

The pumping plant required for the foundation trench consisted of three Worthington compound pumps, each having a nominal capacity of 4,000,000 gals. in 24 hours against a head of 90 ft.

FORCE EMPLOYED, ETC.—When the construction was at its height the contractors employed a force of about 1,564 men.

In performing the work covered by their contract, including highways, etc., the contractors used about 381,000 bbls. of American cement, 365,000 bbls. of Portland cement, and 125,000 tons of coal. All of this material had to be hauled by teams from Croton-on-Hudson to the dam, as the contractors were prevented from building a railroad from the N. Y. C. & H. R. R. to their work on account of charters that had been obtained by private parties, who wished to sell these charters to the contractors at exorbitant prices.

ENGINEERS.—The plans for the New Croton Dam were prepared by the late A. Fteley, Chief Engineer of the Aqueduct Commission. The construction of the work was carried on under the direction of Mr. Fteley from Sept. 1, 1892, to Jan. 1, 1900, when he resigned on account of ill health. Mr. W. R. Hill, M. Am. Soc. C. E., succeeded Mr. Fteley as Chief Engineer and directed the work of construction until he resigned on Oct. 14, 1903. Mr. J. Waldo Smith, M. Am. Soc. C. E., was appointed on Oct. 15, 1903, Chief Engineer of the Aqueduct Commission and served in that capacity until Aug. 1, 1905, when he resigned. Mr. Walter H. Sears, M. Am. Soc. C. E., was placed in charge of the work as Acting Chief Engineer, and on Jan. 19, 1906, the Aqueduct Commissioners appointed him Chief Engineer.

Mr. Charles S. Gowen, M. Am. Soc. C. E., was in immediate charge of the work as Division Engineer from the beginning of the construction until Aug. 31, 1905, when he resigned. He has described the construction of the foundations of the dam very fully in a paper read before the American Society of Civil Engineers (see Vol. XLIII., p. 469), and has discussed the important changes made in the plans by substituting a masonry dam for the proposed earthen dam in a second paper read before that Society on Jan. 18, 1906. On Oct. 15, 1905, Mr. Frederick B. Rogers was appointed as Mr. Gowen's successor. The following Assistant Engineers were in immediate charge of the construction of the dam under the direction of the Division Engineer: B. R. Value, Sept. 1, 1892, to June 1, 1900; F. B. Rogers, June 1, 1900, to Oct. 15, 1905; C. E. Smith, Oct. 15, 1905, to completion.

CONTRACTORS.—The contract for constructing the New Croton Dam was awarded on Aug. 26, 1892, to James S. Coleman, the lowest bidder at his bid of $4,150,573. Mr. Coleman assigned the contract for the construction of the dam on Jan. 2, 1895, to the firm of Coleman, Ryan & Brown, who on July 13, 1899, assigned the contract to Coleman, Breuchaud & Coleman. The original contractor, Mr. James S. Coleman, was the senior member of both of the firms mentioned above.

PROGRESS REPORT OF THE MUNICIPAL OWNERSHIP COMMISSION OF THE NATIONAL CIVIC FEDERATION.

As many of our readers know, the National Civic Federation some months ago appointed a large "Commission on Public Ownership and Operation." Mr. Melville E. Ingalls, of the Big Four R. R., Cincinnati, is Chairman of the Commission, and Mr. Edward A. Moffett, Editor of "The Bricklayer and Mason," Indianapolis, Ind., is Secretary. A Committee on Investigation, of 21 members, has been engaged in active work for several months.* Through the courtesy of Mr. Moffett we are enabled to present the following progress report on the work of the commission to date, and also a statement of the work yet remaining to be done:

THE INVESTIGATION ABROAD.

Fifteen members of the Committee of Twenty-one sailed from New York on May 22, and completed their work abroad in six weeks. They began their itinerary, arranged in advance by Messrs. Maltbie and Sullivan, who, with eight experts, had preceded the committee three months, at Dublin, and concluded their labors at London. In all their examinations the committee consulted with the engineers and accountants. Not only did these technicists accompany the committee upon its visits to the many plants inspected, but they were also engaged—in pairs, the one the nominee of the pro, the other of the anti-members—in completing the critical examination of the plants coming under their respective jurisdiction.

The experts were: Street Railways—Norman McD. Crawford (Hartford, Conn.). Gas—J. R. Klumpp (Germantown, Pa.), Wm. Newbigging (Manchester, England). Electric Lighting and Power—J. H. Woodward (London), A. E. Winchester (South Norwalk, Conn.), Messrs. Warwick, Mitchell & Co. (New York and London) and Robert C. James (Wallingford, Pa.) acted as accountants.

*The representative character of the committee may be seen from the list of members, which, besides Messrs. Ingalls and Moffett, includes the following: Dr. Albert Shaw, Vice-Chairman (Editor Review of Reviews), New York City; Talcott Williams (Editorial Writer, the Press), Philadelphia, Pa.; W. D. Mahon (President Association Street Railway Employees), Detroit, Mich.; Prof. Frank J. Goodnow (Columbia University), New York City; Walton Clark (Third Vice-President The United Gas Improvement Co.), Philadelphia, Pa.; Edward W. Bemis (Superintendent Water-Works), Cleveland, Ohio; Prof. John H. Gray (Northwestern University), Evanston, Ill.; Walter L. Fisher (Secretary Municipal Voters' League), Chicago, Ill.; Timothy Healy (President International Brotherhood Stationary Firemen), New York City; William J. Clark (General Manager Foreign Department, General Electric Co.), New York City; H. B. F. Macfarland (President Board of Commissioners, District of Columbia), Washington, D. C.; Daniel J. Keefe (President International Longshoremen's Association), Detroit, Mich.; Prof. Frank Parsons (President National Public Ownership League), Boston, Mass.; Prof. John R. Commons (Wisconsin University), Madison, Wis.; J. W. Sullivan (Editor Clothing Trades' Bulletin), New York City; Prof. Leo. S. Rowe (University of Pennsylvania), Philadelphia, Pa.; F. J. McNulty (President International Brotherhood of Electrical Workers), Washington, D. C.; Albert E. Winchester (General Superintendent City of South Norwalk Electric Works), South Norwalk, Conn.; Charles L. Edgar (President The Edison Electric & Illuminating Co.), Boston, Mass.; Milo R. Maltbie, New York City.

Labor conditions in the plants chosen for investigation were investigated by Prof. Commons and Mr. Sullivan, of the committee.

The data these experts were required to obtain had all been indicated beforehand in very comprehensive schedules, described in the April number of "The National Civic Federation Review." The committee will be largely guided by these and the American schedules in framing its final report.

The cities visited and the kind of plants examined were as follows:

Dublin	Street Railways	private
Glasgow	Street Railways	public
	Electric	public
	Gas	public
New Castle-on-Tyne	Electric	private
	Gas	private
Manchester	Electric	public
	Street Railways	public
	Gas	public
Leicester	Gas	public
	Electric	public
	Street Railways	public
Sheffield	Gas	private
Birmingham	Gas	public
Liverpool	Electric	public
	Street Railways	public
Norwich	Street Railways	private
London	Electric	public and private
	Street Railways	private
	Gas	private

At Glasgow the committee's work was especially promoted by the fact of its having the very friendly cooperation of so noted an exponent of municipal ownership as Manager Dalrymple of the city's tramways. At London similar assistance was rendered by Sir Clifton Robinson, whose interests in private companies is not exceeded by those of any other man in Great Britain.

Hearings were held at London at which leading exponents of company management were heard. Among those who attended these hearings were Lord Avebury, Mr. Sydney Morse, President of the Chamber of Commerce; Mr. Emil Garcke, of the Industrial Freedom League; Mr. Dixon H. Davies, solicitor, and Mr. Robert P. Porter, of the London "Times." The principal exponents of municipal ownership were also heard. Among the latter were Mr. T. McKinnon Wood, of the London County Council; Mr. J. Allen Baker, Chairman of the London Municipal Tramways; Mr. Robert Donald, of the London "Chronicle," and the Rt. Hon. John Burns, President of the Local Government Board.

From the very beginning great interest was manifested in the work of the commission. Boards of trade, private companies, city governments, labor leaders, members of Parliament, officials of the National Government, representatives of rate payers' associations—all seemed interested, and every facility was placed at the command of the committee

The general sentiment was that the report of the commission should be of no less value to the people of Great Britain and Ireland than to the people of America. The fact that so many men drawn from different walks of life, and of such diversity of opinion, could be gotten together and dispatched upon so important a mission, was much commented upon; as was the further fact, that they had set out to determine the actual conditions in each case, by employing a corps of engineers and accountants. In short, the commission and its sponsors, the National Civic Federation, were warmly commended for having undertaken a work of such manifest importance to cities.

THE FUTURE WORK OF THE COMMITTEE.

The last meeting held in London adopted a resolution outlining a plan for the accomplishment of the remaining work of the committee. This resolution provides:

That as schedules are completed, copies of same be promptly furnished members of committee; that Dr. Maltbie prepare a history of parliamentary action in relation to the municipal utilities under investigation; Prof. Goodnow, a report on political conditions in the municipalities of the United Kingdom as compared with such conditions in the United States, same to include a discussion of the relation of said political conditions to public and private operation of the particular municipal utilities; Profs. Bemis and Parsons and Messrs. Walton Clarke and Edgar, either jointly or individually, such statements for the plants investigated here and abroad; that the schedules for each plant be collated in a clear, concise statement for the use of the committee in drafting its report; that the officers of the committee prepare a general statement of conclusions and recommendations that may be used as a basis of discussion and adoption with such emendation as the committee may order, etc.

In this country the work of investigation is almost completed. The cities that have been visited are: Wheeling, Allegheny, Indianapolis, Chicago and South Norwalk; a number of other cities have been examined by the experts and by members of the committee whose work has been specialized. The experts employed in the American investigation are: Gas—J. R. Klumpp, Fred. C. Hornett (Toronto), A. E. Forstall (New York). Electric Lighting and Power—C. E. Phelps, Jr. (Baltimore), Thos. Stebbins (Columbus, Ohio), A. E. Winchester (South Norwalk, Conn.). Water—Dabney H. Maury (Peoria, Ill.). Accountants—Marwick, Mitchell & Co.

A report upon the Massachusetts method of regulating the electric lighting industry is being prepared by Alton D. Adams (Worcester) and C. I. R. Humphreys, of Humphreys & Glasgow (New York).

Expert work not technical in character in relation to the plants selected is being performed by Prof. Gray, and Mr. Fisher has prepared a report upon the history of the municipal lighting plant of that city; Prof. Rowe has made a similar report on the gas question in Philadelphia. The special investigation into labor conditions is now being completed by Prof. Commons and Mr. Sullivan.

It is expected that Cleveland, Philadelphia and one or two other large cities will be visited by the committee within the next thirty days. After which the sub-committees provided for in the resolution referred to will complete the duties assigned them. This will be followed by one or more meetings of the committee, at which its report will be drafted.

At the present time the work of collating the matter contained in the completed schedules—the data gathered by the experts—in such a way as to make its assimilation more easy, is now being proceeded with.

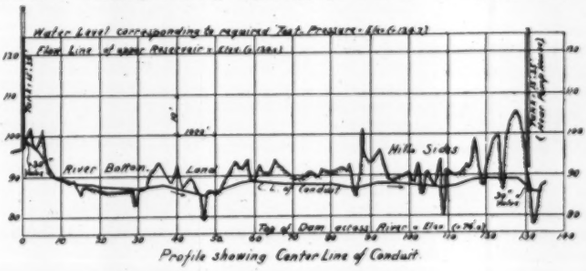
It is expected that the committee will be ready to report to the entire commission about Dec. 1, 1906.

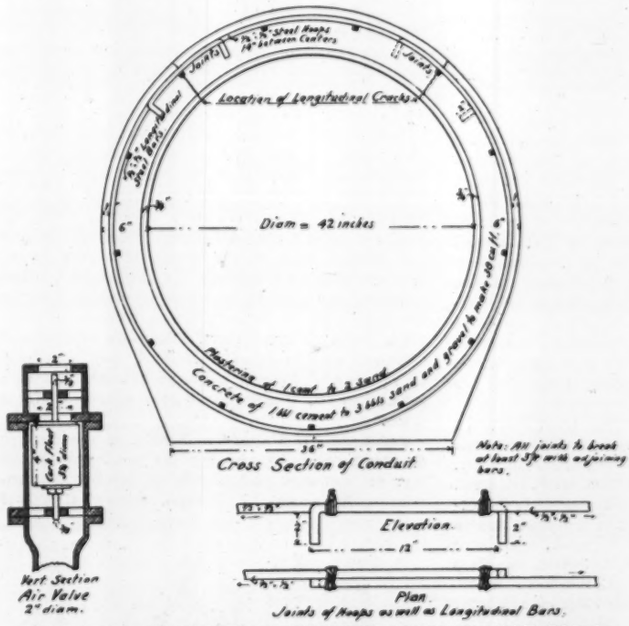
A NOVEL DESIGN FOR A REINFORCED CONCRETE WATER-WORKS CONDUIT.

By "N. W."

The experience from works which have not altogether proven a success frequently furnishes material for discussion which afterwards may prove of great value. A few details of a reinforced concrete conduit, recently built for the water-works of a Southern city, are therefore brought to the attention of readers versed and interested in that class of work.

The conduit (see profile) passes through materials of varying bearing capacity; part of it rests almost on the top of the alluvial deposits in the river bottom, subjected to overflows; parts rest on good foundation; parts are left exposed to the sun and the action of the elements, while other parts are deep in the ground. Where depressions are crossed, the conduit is supported by piers placed from 15 to 25 ft. apart; it carries the weight of itself and the water in it as a continuous girder, and is provided with additional reinforcement for tension at the bottom, but with none at the top. The unit pressure on the ground appears to be far greater under the piers than under the conduit proper, before it reaches the piers. All these matters have their bearing on the numerous cross-cracks that have made their appearance.


Water Level corresponding to required Test Pressure
Flow Line of 42in. Conduit
River Bottom.
Land
Hills Sides
C. L. of Conduit
Top of Dam across River
Profile showing Center Line of Conduit


Location of Longitudinal Cracks
Diam = 42 inches
Cross Section of Conduit
Note: All joints to break at least 3ft with adjoining bars.
Elevation.
Plan
Joints of Hoops as well as Longitudinal Bars.
Vert. Section Air Valve 2" diam.

DETAILS OF REINFORCED CONCRETE CONDUIT BUILT FOR A SOUTHERN CITY.

The accompanying profile shows the pressure to which the conduit may be subject, and also that the maximum test pressure at the lowest place is about 39 ft. or 17 lbs. per sq. in. The cross section shows the general design; but there are special sections with reinforcements in several places. The method of reinforcement is best explained by reference to the accompanying details. The ends of all bars are bent at right angles not less than 2 ins., and the joint with the following bar made by lapping them 12 ins. and wrapping with No. 16 wires. The joints of the hoops are staggered. As it is only required that the end of the bars shall lap joints at least 3 ft. with adjacent and parallel ones, it will be seen that there may be six joints in a cross section with only seven bars of full strength, and that the same may be the case 2 ft. distant from said section; this is probably the case in most places where the longitudinal bars have been joined. All steel bars are smooth, and are ½ × ½-in. in section. Is this steel reinforcement sufficient to take up the tensional stresses that ordinarily can be expected on same, and what is the strength at the joints of the bars?

It was required that the concrete should be composed of 1 bbl. packed Portland cement, 3 bbls. sand, and enough gravel to make 30 cu. ft. of concrete; also that the mortar for the inside plastering be composed of 1 bbl. packed Portland cement and 2 parts sand. Soft soap and alum were used in the mixtures to render them impervious.

A few 2-in. air valves (see detail) were placed at the summits; they failed to act as some one must have expected them to do, and would not open by themselves against the air pressure, when the conduit was filled. The compressed air caused a rush whenever the valves were forced down, and that may have had something to do with the first breaks.

Long stretches of the conduit are in fair shape and others are in bad condition.

It was reported that work was commenced in January and completed in August, 1904. So far everything was lovely. A couple of preliminary tests were then made under the direction of the engineer; according to a reliable source about 3,000 ft. of longitudinal cracks, or leaks, made their appearance on each occasion; in addition to this a number of transverse cracks appeared, and these, together with the 6,000 ft. of longitudinal cracks, were patched by the contractors under the direction of the engineer; but all without permanent results. On Nov. 24, 1904, the contractors refused to attempt further patchwork.

During 1905 patchwork or repairs were made by the city under the direction of the same en-

gineer, assisted by other concrete experts, until in August and September of said year they managed to make some tests that appeared to be very satisfactory. A short time afterwards it became known that the conduit was in about as bad shape as ever before, and an inspection party in January, 1906, estimated the daily loss by leakage to be about 1,200,000 gals. Another appropriation for repairs has been made and bids for same received; but the officials have not agreed as to the best methods of doing the work. At last accounts there were 24 large cross-cracks; but it is said that the longitudinal cracks are no longer as much in evidence as in the beginning. The latter are caused by the pressure, and can not be expected to show much without said pressure; the cross-cracks arise from several different causes, and are mostly found to be widest at the top and tapering toward the center; however, there are also several of them at the bottom. There seem to be certain relations between the cracks crossing each other at right angles; this is probably caused by the tension on the concrete at right angles with the bars diminishing the grip at the joints.

DEVELOPMENTS IN THE TRANSCONTINENTAL RAILWAY SYSTEM.

In all the network of main-line railways in the United States, there is no one line extending from the Atlantic to the Pacific under one ownership or management. In this respect there is a marked difference from the Canadian railway system; for the Canadian Pacific Ry. has its own transcontinental line, the Grand Trunk Pacific Ry. will have a second (although a part of this will be owned by the government), and the Canadian Northern Ry. seems likely to eventually complete a third route from ocean to ocean. The term transcontinental railway is, however, commonly applied to the trunk lines from the Mississippi River to the Pacific. In the map of the transcontinental railway system which is presented herewith we have omitted the new Canadian lines, as these were described in our issues of April 5, 1906, and Oct. 22, 1903. The Canadian Pacific Ry. is shown, however, on account of its connections and close relations with the railway system of the United States. A description of the transcontinental lines in this country, with their profiles, was given in our issue of June 10, 1897.

Most of these so-called transcontinental lines commence at points on the Great Lakes or the Mississippi River, and several of the through routes are composed of two or more railways. There are various connections from these points to points on the Atlantic seaboard, but no trains and very few cars are run through east or west beyond the eastern terminals of the transcontinental lines. A detailed description of the several routes or lines would not be of particular interest, but we may briefly review some of their characteristics in connection with the several important new lines and extensions which are shown on the accompanying map and are described more fully below.

The two northern lines are the Great Northern Ry. and the Northern Pacific Ry., each of which starts from St. Paul, on the Mississippi River, and terminates at Seattle, Wash. (1,829 miles), and from Portland, Ore. (2,053 miles), respectively. Each of these roads has a direct line to Duluth, at the head of Lake Superior, and there are several connecting lines between St. Paul and Chicago. The Chicago, Milwaukee & St. Paul Ry. has now under construction a Pacific extension which will form a third northern line, from St. Paul to Seattle (about 1,900 miles), practically parallel with the Northern Pacific Ry., which it crosses several times; this road, however, will not depend upon foreign connections, having its own line from St. Paul to Chicago. There is still another route from St. Paul, that of the Minneapolis, St. Paul & Sault Ste. Marie Ry., which runs northwest to Pasqua on the Canadian Pacific Ry., and is operated in direct connection with the latter road. The

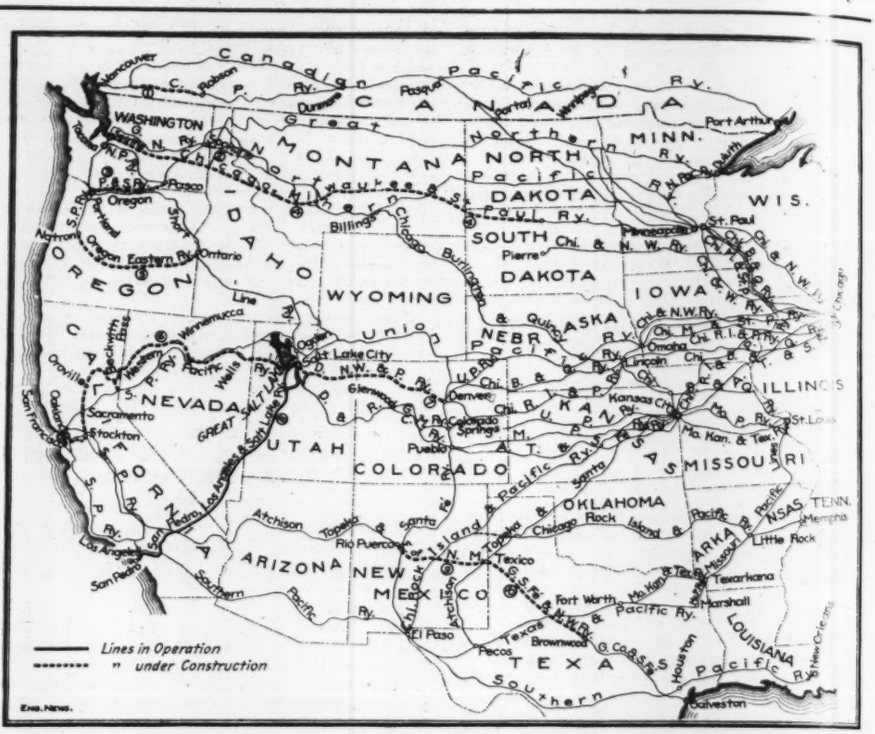


FIG. 1. MAP OF THE TRANSCONTINENTAL RAILWAY SYSTEM SHOWING LINES IN OPERATION AND UNDER CONSTRUCTION.

Chicago & Northwestern Ry. is now extending its own line westward across South Dakota from the Missouri River at Pierre, and it has many times been rumored that this road intends eventually to push its line west to the Pacific coast, about midway between the Northern Pacific Ry. and the Union Pacific Ry., but at present there seems to be nothing more tangible or definite than this rumor.

Across the center of the western part of the continent is the first of the transcontinental lines, formed by the Union Pacific Ry. from Omaha (on the Missouri River) to Ogden, and the Central Pacific Ry. from Ogden to San Francisco, 1,786 miles in all. Within recent years, the great open belt of the country between the northern and central routes has been crossed diagonally by two lines: (1) the Oregon Short Line route connecting the Union Pacific Ry. with Portland, and (2) the Chicago, Burlington & Quincy Ry. extension from Lincoln, Neb., to Billings, Mont., thus affording (with the Northern Pacific Ry.) direct routes from St. Louis, Kansas City and Chicago to the Pacific. The "Burlington" railway has also a line of its own from Chicago to Denver; which affords still another route to the Pacific. Between Omaha and Chicago (as between St. Paul and Chicago) there are a number of railways operating through service to the Pacific coast over various connections.

South of the Union Pacific Ry. is the Denver & Rio Grande Ry., joining the Southern Pacific Ry. at the west and having a number of connecting lines east to Chicago, Kansas City and St. Louis; it thus affords various combinations for through service. South of this group of lines again are the two southern routes: (1) the Atchison, Topeka & Santa Fe Ry. from Chicago and Kansas City south and west to San Francisco (2,576 miles), and with a Gulf Coast connection under construction; (2) the Southern Pacific Ry. from New Orleans to San Francisco (2,489 miles). The latter also forms part of two or three routes in combination with the Chicago, Rock Island & Pacific Ry., the Texas & Pacific Ry. and the Missouri Pacific System. An examination of the map will show very clearly the several lines and routes referred to, and their relation to one another. The Chicago, Rock Island & Pacific Ry. is also completing an extension which will give it a line from El Paso (on the Southern Pacific Ry.) to Memphis, Tenn., available for connections east of the Mississippi River.

Ten important additions to the transcontinental railway system are indicated on the map, one of which is in operation while the others are under construction. Some particulars of these new lines are given below.

(1) CANADIAN PACIFIC RY.—A few years ago this railway began extending its Dunmore and Lethbridge branch through the Crows Nest Pass and into the Kootenay region, and surveys have been made for the continuation of this line to the Fraser River, connecting with the present main line at Hope, B. C., and so forming an alternative southern route. A number of improvements have also been made on the present line, while between Winnipeg and Fort William

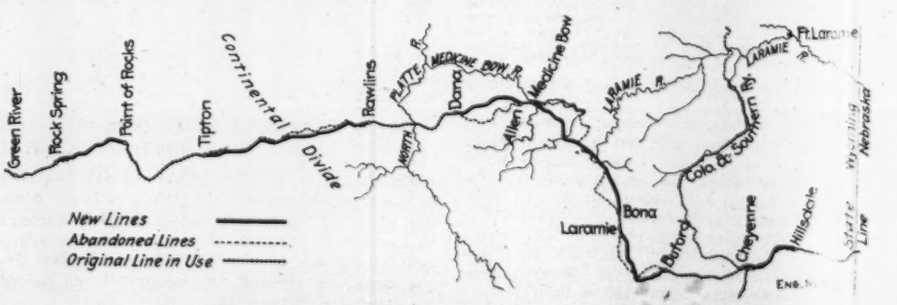


FIG. 2. MAP OF IMPROVEMENTS ON UNION PACIFIC RY. IN WYOMING.

TABLE I.—IMPROVEMENTS ON THE UNION PACIFIC RY.

Location	Length of Line: Old miles	Length of Line: New miles	Length of Line: Dist. saved miles	Maximum Grade: Old Line: East bound: ft. per mile	Maximum Grade: Old Line: East bound: length ft.	Maximum Grade: Old Line: West bound: ft. per mile	Maximum Grade: Old Line: West bound: length ft.	Maximum Grade: New Line: East bound: ft. per mile	Maximum Grade: New Line: East bound: length ft.	Maximum Grade: New Line: West bound: ft. per mile	Maximum Grade: New Line: West bound: length ft.	Maximum Curvature Degrees: Old	Maximum Curvature Degrees: New	Date of Completion
[illegible] (Omaha) to Lane	20.53	11.61	8.92	21	1,250	37	1,400	26	13,600	32	13,800	3	3	In progress
[illegible] to Cheyenne	19.96	19.83	0.13	35	14,300	35	12,000	37	3,350	37	5,000	3	3	1904
[illegible] to Laramie	29.47	29.47	—0.21	91	7,000	80	8,700	43	15,700	43	2,500	6	4	1900
[illegible] to Medicine Bow	66.89	51.11	15.78	48	2,000	46	2,400	43	16,327	43	10,300	6	3	1900
[illegible] to Dana	28.10	24.36	3.74	50	9,900	67	10,200	43	4,900	43	7,800	6	4	1900
[illegible]as to Tipton	58.90	57.49	1.41	69	2,000	62	3,800	43	7,800	43	15,200	6	3	1900
[illegible] of Rocks to Rock Springs	25.06	24.81	0.25	53	2,900	53	1,000	43	2,500	42	500	5	5	In progress
[illegible]a City to Topeka	67.24	67.12	0.12	79	500	79	300	19	1,400	18	2,000	6	4¼	1906

Connections.	Distances. miles.	Highest elevation above sea level, ft.
Council Bluffs, Iowa, to Green River, Wyo.	817.56	8,010
Kansas City, Mo., to Denver, Colo.	639.40	5,695
Denver, Colo., to Cheyenne, Wyo.	106.67	6,296
Cheyenne, Wyo., to Green River, Wyo.	307.74	8,010

the line will be largely rebuilt in order to obtain better grades and alinement for heavy traffic. The length of the present line is 2,904 miles from Montreal to Vancouver.

(2) NORTHERN PACIFIC RY.—This is a short piece of line giving a more direct and favorable route into Spokane. Along the main line of this railway work has been in progress for several years in the way of general improvement.

(3) PORTLAND & SEATTLE RY.—This is a line about 250 miles long in the joint interests of the Great Northern Ry. and the Northern Pacific Ry., lying along the north bank of the Columbia River, westward from Pasco, and giving a direct route into Portland, Ore., which is at present accessible only by way of Seattle and Tacoma.

(4) CHICAGO, MILWAUKEE & ST. PAUL RY.—This is the longest of all the new lines, and will form an entirely new route from Chicago and the Mississippi River to the Pacific Coast. From St. Paul, the railway has a line extending across South Dakota to Evarts, on the Missouri River, 386 miles; from this point the new line will run direct to Seattle, Wash., and will be about 1,500 miles in length, giving a route of 1,900 miles between St. Paul and Seattle (or 2,300 miles from Chicago). Work is already in progress at several points along the route. Mr. E. J. Pearson is Chief Engineer.

(5) OREGON EASTERN RY.—This is a line about 400 miles long, in the Southern Pacific Ry. interests, running through an undeveloped part of the state and extending from Ontario, on the Oregon Short Line Ry., to Natron, the present terminus of a Southern Pacific Ry. line from Portland.

(6) WESTERN PACIFIC RY.—This line is equally important with the Chicago, Milwaukee & St. Paul Ry. extension to the coast, and perhaps even more important, since it will form a link in the chain of lines of the Gould System extending from the Atlantic to the Pacific and all under one ownership. The Gould System already comprises the Wabash Ry. from Pittsburg to St. Louis, the Missouri Pacific Lines to Pueblo and the Denver & Rio Grande Ry. to Salt Lake City. The maximum grades on the entire line of the Western Pacific Ry. are of 1%, and the sharpest curves are of 6°, with the exception of a few 10° curves in the Feather River canyon, east of Oroville, Cal. The total distance from Salt Lake City to San Francisco (or Oakland) will be about 920 miles. Contracts have been let for all the work in California (380 miles) and in Utah (122 miles), and this is under construction. Bids have also been received for 102 miles of the work in Nevada (422 miles). In California, about 4,000 men are at work, and some 30 miles of grading are completed at various points; 18 miles of main track have been completed west from Stockton. The elevation at Salt Lake City is 4,213 ft.; crossing the range east of the desert, the elevation is 4,640 ft. at the Grass Mountain Pass, and beyond the desert the line rises to the rim of the Salt Lake basin at an elevation of 5,905 ft. in the Silver Zone pass; there is then an almost continual fall to the California state line, except for a short ascent to cross the Antelope Range (4,524 ft.). From Wells to Winnemucca the line lies along the Humboldt River, and parallels the Southern Pacific Ry. At the state line, the line again begins to rise and attains an elevation of 5,018 ft. in the Beckwith Pass, beyond which there is a continuous fall to Oroville, 207 ft. elevation, and Stockton, 20 ft. At Altamont is a summit of 750 ft. elevation, and then the line falls to practically sea-level at San Francisco. The branch line near the California state line is the Boca & Loyalton Ry., a subsidiary concern. Mr. Virgil A. Bogue, M. Am. Soc. C. E., is chief engineer. The following table shows distances and grades:

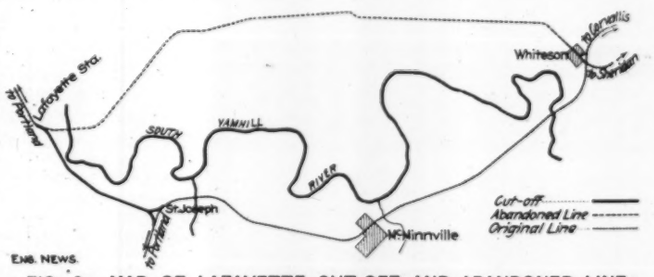


FIG. 3. MAP OF LAFAYETTE CUT-OFF AND ABANDONED LINE: SOUTHERN PACIFIC RY.

	Distance. Miles.	Elevation. Feet.	Grades (max.) Per ct.
San Francisco	—	10	—
Hayward	28	108	+0.25
Altamont	60	750	+0.80
Tesla	75	140	—1.00
Marysville	180	82	—0.30
Oroville	207	198	+0.40
Beckwith Pass	342	5,018	+1.00
State Line	380	4,015	—0.80
Sand Pass	395	4,121	+0.40
Smoke Creek desert and Black Rock desert,	410 to 470	3,883 to 3,921	—0.40 to +0.40
Antelope Range, summit	490	4,524	+0.40
Mile	500	4,185	—1.00
Wells	717	5,788	+0.40
Silver Zone Pass	773	5,905	+0.80
State Line	802	—	—
Edge of Gt. S. L. Desert	806	4,236	—1.00
Edge of desert	850	4,281	—
Grass Mt. Pass	880	4,640	+0.80
Mile	875	4,233	—0.80
Salt Lake City	924	4,213	—

(7) DENVER, NORTHWESTERN & PACIFIC RY.—This is now under construction and will form practically a direct east and west line between Denver and Salt Lake City, 569 miles in length, as compared with 741 by the Denver & Rio Grande Ry. There are 126 miles completed and in operation west from Denver, and 80 miles more are under construction. The maximum grades are 2%, with a maximum length of 11 miles eastbound and 42 miles westbound; the sharpest curves are of 12°. The maximum summit elevation will be 9,930 ft. on the main line, but the temporary line over the Continental Divide (to be superseded by a tunnel) has a summit elevation of 11,660 ft. Mr. H. A. Sumner is chief engineer. This railway was described in our issue of March 9, 1905.

(8) SAN PEDRO, LOS ANGELES & PACIFIC RY.—This was the first of the new railways in the transcontinental system to be completed, and was opened to traffic in 1905. It gives a route of 770 miles from Salt Lake City to Los Angeles or 797 miles to the new port of San Pedro, Cal. Its through service is operated in connection with the Union Pacific Ry. and the Chicago & Northwestern Ry. The highest summit elevation is 5,971 ft. at Crestline, Nev., where the line crosses the edge of the great Salt Lake basin; the maximum grades are mainly 1%, but with one stretch of 2% and a short pusher grade of 2.2%. The sharpest curves are of 3° and 5°. This railway was described in our issue of June 22, 1905, and Mr. E. C. Tilton, chief engineer, states that no important line or grade changes have recently been made. We are informed, however, that some extensive washouts occurred last spring in Nevada, and that the line was rebuilt at a higher elevation to avoid future trouble.

IMPROVEMENTS ON THE SOUTHERN PACIFIC RAILWAY SYSTEM.

As already mentioned, extensive improvements have been in progress for some years past on the various transcontinental systems, and prominent among these are the several lines included in the Southern Pacific Ry. System. For particulars of these we are indebted to Mr. Julius Kruttschnitt, Director of Maintenance and Operation.

UNION PACIFIC RY.—The map, Fig. 2, shows some of the changes in the main line between Cheyenne and Ogden, and Table No. 1 gives particulars of the distances, grades and curves on the original and revised lines at points where improvements have been made.

OREGON SHORT LINE RY.—No important line changes have been under construction recently.

OREGON RAILWAY & NAVIGATION CO.—The statement in Table II. shows the improve-

TABLE II.—Improvements on the Oregon Ry. & Navigation Co.

	O. Ry. & N. Co.: Troutdale to Bonneville.	Dalles and Celilo.	S. Pac. Ry. Lafayette & St. Joseph.
Original maximum grade.	0.51%	1.25%	1.4%
Max. grade east-bound on changed line	0.5%	0.2%	0.5%
Max. grade west-bound on changed line	0.5%	None	None
Length of max. grades east-bound	2,800 ft.	6,500 ft.	3,300 ft.
Length of max. grades west-bound	5,300 ft.	.....	.....
Highest elevation in changed line	85 ft.	133 ft.	192 ft.
Sharpest degree of curvature	5° 20′	2°	6°
Distance between terminals of changed line	24.13 mi.	1.32 mi.	2.33 mi.

TABLE III.—IMPROVEMENTS ON THE GALVESTON, HARRISBURG & SAN ANTONIO RY.

Cut-off.	Marfa: Old line.	Marfa: Cut-off.	Paisano: Old line.	Paisano: Cut-off.	Marathon: Old line.	Marathon: Cut-off.	Dryden: Old line.	Dryden: Cut-off.	Alleyton to Columbus.* Old line.	Alleyton to Columbus.* Cut-off.
Max. grade: east; p. ct.	1.00	1.07	0.99	0.90	0.20	1.00	0.00	0.79	0.964	0.30
Length of same, ft.	821	3,000	206	988	992	800	...	1,600	1,400	2,000
Max. grade: west; p. ct.	0.61	0.90	1.00	1.00	1.00	1.00	1.00	1.00	0.928	0.30
Length of same, ft.	1,000	500	647	1,376	1,674	6,500	1,000	3,000	1,400	5,700
Max. elevation, ft.	4,818	4,815	5,084	5,075	4,212	4,212	2,093	2,102	2,183	2,040
Sharpest curve, degr.	8	3	10	4	10	2	8¼	4	4	2½
Length of line, ft.	13,880	12,698	17,158	12,238	18,472	16,494	18,805	17,645	19,742	16,790
Saving in distance, ft.	.....	1,182	.....	4,920	.....	1,978	.....	1,210	.....	2,952
Degrees of curvature	549° 48′	106° 04′	826° 02′	240° 54′	386° 50′	24° 02′	328° 37′	152° 53′	110° 19′	96° 25′
Saving in curvature	.....	443° 42′	.....	585° 08′	.....	362° 57′	.....	174° 44′	.....	13° 44′

*Under construction.

ments effected by changes between Troutdale and Bonneville and between Dalles and Celilo, which changes do not diverge very far from the original location, but consist mainly of straightening the old line. The table also shows the improvements effected on the Southern Pacific Ry. lines in Oregon by the construction of a cut-off between Lafayette and St. Joseph (near Portland, Ore.). The construction of this short piece of line results in the abandonment of the old route between Whiteson and Lafayette, about 8½ miles, as shown by the map, Fig. 3.

SOUTHERN PACIFIC RY. (Pacific System).—Since the completion of extensive line changes on the Central Pacific Ry. line, including a cut-off

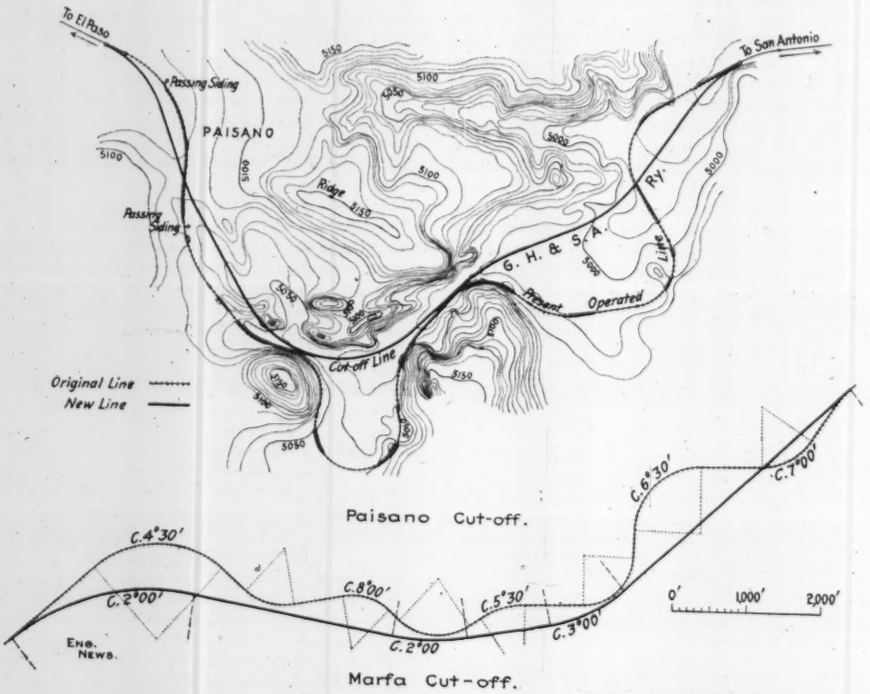


FIG. 4. MAP OF PAISANO AND MARFA CUT-OFF LINES: GALVESTON, HARRISBURG & SAN ANTONIO RY. (SOUTHERN PACIFIC RAILWAY SYSTEM).

over the Salt Lake Division, which has been described in our columns, there have been no extensive line changes on this system except that now going on by the construction of the Bay Shore cut-off from San Francisco along the west shore of San Francisco Bay to a connection with the existing main line at San Bruno. This will shorten the line three miles and reduce the maximum grade between those points from 2.2% to 0.8%.

LINES IN TEXAS AND LOUISIANA.—In Table III. are shown the improvements effected on the El Paso Division of the Galveston, Harrisburg & San Antonio Ry. The principal features of these improvements are in the straightening of the location, substituting comparatively direct lines with long tangents and fewer and easier curves for circuitous lines having numerous and sharp curves. This will be seen by the figures in Table III. and by the plans of the Marfa and Paisano cut-offs in Fig. 4.

A FLEXIBLE WHEEL recently placed on the market by Vieo, Ltd., of London, England, consists of a floating wooden rim, upon which is mounted a weldless steel tread, perforated by holes fitted with wooden plugs. Forward and reverse felloe drivers revolve in lubricated ferrules and engage with the rim drivers. The eccentricity of the rim and felloe causes each of four sets of stops to come successively into action at a practically definite point of revolution of the wheel. There is always a direct drive between the parts, as one set does not disengage until the other set has come into action. The principal feature of this type of flexible wheel is that the drive is not transmitted through the resilient medium, which in this case consists of rubber rollers having different degrees of elasticity in proportion to the load to be carried.

A REMARKABLE INFLUX OF IRON AND MANGANESE INTO THE UNDERGROUND WATER SUPPLY OF BRESLAU, GERMANY.

Translated by Allen Hazen,* M. Am. Soc. C. E.

[The August number of "La Technique Sanitaire" (Brussels) contains an interesting article upon the change in the mineral composition of the water of Breslau, by J. Vancl, of Smichov, Bohemia, which stated:]

A very singular and unfortunate phenomenon was noticed toward the end of March, 1906, in the water supply of the city of Breslau. After a moderate flood in the Oder, which flooded a part of the region about the wells, the character of the water was rapidly changed in its chemical and organic contents and was no longer potable or usable for industrial purposes. It had a disagreeable odor and a metallic and disagreeable taste. As it came from the wells it was limpid and of a light green tint, but it quickly became turbid and gave rise to a flocculent or rusty precipitate. Linen washed with this water became yellow and covered with brown patches.

It was at first believed that the change in the water was a temporary incident, but the flood passed and the water still remained of unsatisfactory quality. It became necessary to abandon a part of the ground water supply and to return again to the river water filtered through the old sand filters.

The city of Breslau, capital of Silesia, had in 1900 about 422,000 inhabitants. Since 1872 it has been supplied by filtered water from the river Oder. The sand filters have given good results; the number of bacteria in the effluent having remained below 100 and the typhoid mortality in the last ten years having ranged from 6 to 11 for 100,000 living.

In 1894, under the direction of M. V. Schneider, an addition to the filters was constructed, although in 1892 C. Flügge, Privy Counsellor and Professor of Hygiene at the Universtiy of Breslau, commenced to make objections to the use of the filtered river water. He recommended the abandonment of sand filters and the substitution of an underground supply. Among other reasons he noted that the increase in the navigation of the river tended to pollute the river and had an unfavorable influence upon the quality of the water, which might in time become serious.

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The municipality, following the suggestions of M. Flügge, undertook to find an underground supply of 16,000,000 gals. per day. In doing this the services of the late A. Thiem, of Leipsic, specialist in securing underground supplies, were obtained. Mr. Thiem made extended studies in the valleys of the Oder and of its tributaries, and discovered an underground current which he calculated would yield 16,000,000 gals. of water per day, with a lowering of the water level of 20 ft., sufficient, as was computed, to supply the city until 1916. This result was declared favorable. The water contained some iron, but it was proposed to remove this iron by the installation of aerators and semi-rapid sand filters. The project of Thiem was accepted with slight modifications. A total of 315 well tubes, 6 ins. in diameter, were driven with a spacing of 69 ft. The three lines of wells were connected with two central receiving wells from which the water was carried to the iron removal plant, and thence flowed to the pumping station near the old filters.

In the annual city report of 1904 it was announced that the project was so far advanced that most of the supply could be obtained from the new source in 1905, and that at the end of the year it was expected that the old supply could be abandoned. The cost of the work had been about six million marks ($1,500,000), but the yield of the wells fell considerably short of the calculations. After a few months of use it was found that with lowering the water level 29½ ft. the whole system of wells, even during the winter months, was not sufficient to supply the actual requirements of the city, amounting to about 10,500,000 gals. per day.

It was under these conditions, with the wells forced to the utmost, that the catastrophe arrived. On March 28, 1906, the water drawn from the wells commenced to have the qualities indicated above. The Institute of Hygiene of the University announced that following a flood in the Oder the quantity of iron contained in the water was increased to such an extent that, on March 30, with the plant at hand, it was impossible to sufficiently remove the iron, and that the water supplied in the city contained a small amount of iron. The phenomenon was believed to be only temporary, however. Hygienically the water was declared to be good.

Soon after it was found that air was being drawn in some cases with the well water, and this seemed to be a disturbing element in the situation.

On March 28 the iron from the two groups of wells was 9 to 18 parts per million, respectively; on March 29 this had increased to 103 and 80 parts per million, respectively. In some individual wells there were from 400 to 600 parts of iron. It was subsequently found that the water contained a large amount of manganese, together with the iron, in solution. On April 4 it was found that the temporary hardness in the well water had completely disappeared. Carbonic acid had been replaced by sulphuric acid in all its chemical combinations, and sulphates were found in place of the carbonates previously existing in the water.

Prof. Flügge, on April 5, declared the water to be unusable. There was nothing to do but to fall back upon the Oder water. This decision was forthwith taken, and on April 8 the old sand filters were put in service and the use of the wells was discontinued.

Various explanations of the phenomenon have been made, but it appears that the reduction in water pressure with the lowering of the water level resulted in the flow to the water layer of water from some underground source not previously having an outlet in that direction, which water contained sulphates and sulphuric acid sufficient to bring about the changes which were observed.

According to the geologist, Dr. Tuhrich, there are in the neighborhood notable tertiary layers containing pyrites in large amounts, and the sulphuric acid may have come from the oxidation of these pyrites in some way. A commission has

been appointed to investigate the matter and to find remedies for it.

The author remarks that

after a year and a half of service, and after the most extended and minute investigations of engineers, geologists, chemists and bacteriologists, this catastrophe had happened, and also that the well supply had only been able to furnish two-thirds of the calculated yield, even under forced conditions.

Certainly the methods of calculation employed in this case must be modified in the future, and filtration, the system for many years esteemed in Germany, but now looked on with less favor, has been brought back in Breslau to its old place of the highest honor. It is accomplishing there again the slow but sure purpose, after the most unfortunate experience with another mode of supply, of which the hygienic superiority has been so loudly proclaimed.

[Adolph Kemna, Manager of the Antwerp Water-Works, in commenting upon this paper, in the same number of "La Technique Sanitaire," says:]

Briefly the facts are these: The supply of the city with filtered river water had been replaced by an underground supply; the cost had been six million of marks; there had been an error in the calculation, as to quantity, in that the amount obtained was hardly 10,500,000 gals. per day in place of the 16,000,000 calculated; it was known that the water contained iron and an apparatus had been provided for removing it, but the quantity of iron in the water rapidly increased to 400 parts per million; the iron removal apparatus did as well as could be expected, but when the water also contained 600 parts per million of sulphate of maganese it was absolutely impossible to longer use the water; the change came rapidly, following a flood in the river inundating the region drained by the wells.

Two theories have been suggested to explain the singular event, first, that there was a break in the clay layer at the bottom of the quaternary which allowed waters from the tertiary to enter under artesian pressure, and second, that the excessive pumpage during eighteen months, combined with the dryness of the season, resulted in lowering the level of the ground water, allowed the air to come in contact with the pyrites, which became oxidized, making sulphuric acid which reacted on the deposits of manganese, and that when the deposits were flooded by the river water the results of these reactions were washed forward to the wells.

The breaking of the clay series seems untenable because the clay layer would hardly be expected to break suddenly and in this way; and, further, the chemical composition of the water from the tertiary formations is not usually of the character of the water drawn from the wells. On the other hand, the water of the wells has the properties that one would expect with the addition of a large amount of acid to the supply, and this accords with the second theory which has been proposed.

The situation in Breslau certainly was not one to justify the abandonment of filtration, but the increasing pollution of the river was considered as a danger, to guard against which radical measures were justified, and Professor Flügge forced this view with tenacity upon the city. The ground water system could be defended as being the most rational. The water was taken at a sufficient depth so that complete filtration was assured. There was, therefore, complete hygienic security. The mineral composition sometimes was less satisfactory, but as against this was the esthetic side; also the iron could be removed from the water.

These are the ideas which have for some time controlled in Germany. The cholera in Hamburg in 1892 demonstrated in a striking manner, by the immunity of Altoona, the efficiency of sand filtration, and Koch, and his school, by no means missed the force of this.

This experience tended to maintain existing conditions for a while, but after a few years there was a marked tendency to change. The official regulations for filtration became more and more rigorous. It was proposed to abandon the filters in places. This has really been done at Berlin; it is being done in Hamburg, and it has been done at Breslau, with what results we are seeing.

The study of the hygienic conditions merits our attention. On Germany's eastern frontier, against Russia, there have been taken for many years a series of measures, and in 1905 these were put to a serious proof. Russia had menaced Europe with an epidemic of cholera. The German scientific organizations arrested the epidemic and saved Europe. At the other side of the Empire, on the western frontier, there were also some significant facts. The local authorities of Gelsenkirchen were followed with a rigor, which was perfectly justifiable, and it was insisted that a new water supply for Metz must be found. The personal nature of the movement is worth mentioning. Without there being any official organization, the reports of the professors of hygiene in the local institutes and in the central institute at Berlin were absolutely harmonious, and these professors were, in effect, the local agents of the Hygienic Institute.

At the congress of Gas and Water-Works Engineers at Hanover, in 1904, the only communication upon the source of water supply was by Professor Gaertner, of Yena, who was an active partisan for the supply of ground water. The municipality of Metz, reluctant to incur the expense, had rejected a new project, but an energetic telegram from the Emperor himself resulted in reconsideration.

A sensational telegram is not such an extraordinary matter, but one would deceive himself if he did not realize the force of this first impulse. The telegram to Metz appears only a part of a well considered and mature plan, and Gaertner's paper was a part of that plan. Sanitary measures were determined in large measure by military necessities. One must maintain the sanitary condition of all frontier districts, so that, at the opening of a campaign, the concentration of troops should not be accomplished by an epidemic, and this explains many matters otherwise not clear.

The military spirit is somewhat different from the scientific spirit. It knows nothing of argument and compromise. It proceeds by orders which are not discussed. The utilization of ground water has become one of these orders. It must be carried out without too much regard to local requirement. For six million marks one might have constructed a great many filters capable of correcting a large amount of pollution, and the results would have been certain.

Temporarily, one is forced back to the use of the filtered river water, the old filters fortunately not having been molested; but it is necessary to advise for the future. Flügge proposes to construct a new series of wells in another place where a repetition of the accident is impossible. This project is meeting with strong opposition, as one can readily understand.

France for a long time was the country where theory and dogma as to ground water was rampant, but she has come back to more rational ideas, and some of her filter installations are now models. At this moment, singularly chosen, Germany is abandoning surface waters and devoting all her energies to securing ground waters.

Destiny has furnished an incident which may teach much and inspire greater prudence in the efforts to reach this end.

[This remarkable incident at Breslau has received scant notice in the German papers, but the following notes have been found in the "Journal für Gasbeleuchtung und Wasserversorgung," June 2, 1906, Vol. XLIX., p. 486:]

In the flood of the river Oder at the end of March very considerable quantities of iron and manganese salts, partly bicarbonates and partly sulphates, were brought into the ground water supply. The change in the character of the water took place very suddenly about twenty-four hours after the land about the wells was flooded.

The collecting system consists of three groups of tube wells, the first with 26 wells and the third with 132 wells, connected by siphons with collecting well No. 1, and the second system with 155 wells, connected with collecting well No. 2.

The wells are in the alluvium on the left bank of the Oder, above Breslau, and are driven down to an impermeable layer, which begins at from 10 to 16 meters under the surface and has a thickness of from 15 to 40 meters. The wells are all 150 millimeters in diameter and 21 meters apart, in the direction of a ground water stream flowing from southeast to northwest, and discharging itself in part in the Oder and in the Ohle, a tributary, and which also is in part fed from these streams in flood periods.

The land about the first and third groups was flooded on March 28 and of the second group partly on March 29.

In all three groups, before the flood, the water level had been reduced very low because of the unusual dryness of the season. The suction pipes often dipped not more than from 30 to 50 centimeters in the ground water in the wells.

When the land was flooded it forced air from the land into the well pipes of the third group, where the surface material is somewhat pervious, and this air interfered with the action of the siphons and required the continuous operation of the air pumps.

The iron increased from 9 and 18 parts per million in the two sets of wells on March 28 to 101 and 20 parts on the 29th, and to 98 and 80 parts on the 31st.

On March 31 there commenced to be trouble with laundries which were colored brown by the water and entirely spoiled. It was also found on this data that there were 50 milligrams of sulphate of manganese in the water, and there seemed to be less iron.

The aerating and filtration arrangement, coke irrigators and gravel filters, followed by sand filters, operated up to that time perfectly, notwithstanding the great quantity of iron. The sulphate of manganese, naturally, they were unable to hold back. The greatest quantity of iron and manganese was shown in the water of the third collection group, and in individual wells went up to 400 parts per million of iron and 600 parts of manganese sulphate. This group, therefore, was shut out to allow the water to rise to its natural level and the normal conditions to return. The displaced water was replaced by filtered Oder water.

Since April 5 the city has been supplied with water from the second group of wells and with filtered Oder water; that is, with about two-fifths ground water and three-fifths filtered river water. The third collection group has been pumped since the first of May and the water treated with lime water and then put over wooden waterfalls back to the Oder. This treatment is adopted to precipitate the iron and manganese before returning it to the river to prevent its killing the fish, as investigation showed that the salts were poisonous to fish.

There is speculation as to the cause of the trouble. The advice of expert hygienists, geologists, engineers and chemists is being secured, and various theories have been proposed, and these investigations are not yet finished.

WATER AND SEWERAGE SYSTEMS for Monterey, Mex., are being built by the Monterey Water-Works & Sewer Co., under a concession granted Mr. William Mackenzie, the owner of the street railway system of Monterey. Two concrete gravity conduits, each of 9,000,000 gals. capacity, will bring water to the city from nearly opposite directions. Each conduit is 19 kilos. (12 miles) long; one will bring water from springs and the other from tunnels driven to intercept the underflow at a depth of some 75 ft. from the surface. The conduits will terminate in a distributing reservoir. The sewerage system will cover the same general territory as the water-works distributing mains. Under the terms of the concession, connections of all houses with the sewerage system will be compulsory and a monthly rental for the use of the system will be charged. Mr. George S. Binckley is chief engineer and manager of construction, and Mr. J. D. Schuyler, M. Am. Soc. C. E., of Los Angeles, Cal., is consulting engineer.

THE APPLICATION OF LARGE GAS ENGINES IN THE GERMAN IRON AND STEEL INDUSTRIES.*

By K. Reinhardt.†

THE DEVELOPMENT OF LARGE GAS ENGINES.

To Great Britain, Germany and Belgium belong the credit of first putting into practice the idea of burning blast-furnace gases directly in gas engines, instead of under steam boilers, as had previously been done. The first attempts in this new direction were made with small en-

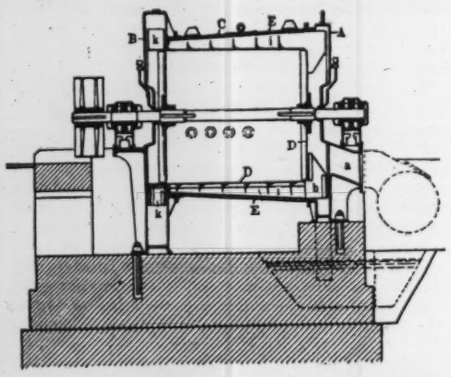

Fig. 1. Side Elevation of a Centrifugal Purifier (Theisen Apparatus) for Blast Furnace Gas.

gines about ten years ago. After these experiments had given satisfactory results and it was found that the thermal value of poor blast-furnace gases, even with defective scrubbing, could safely be transformed into mechanical work in the gas engine, there arose a demand for large gas engines. These sudden requirements placed gas-engine builders in an embarrassing position, because up to that time the gas motor was thought to have reached its limit of size with 100 to 150 Eff. HP. in a single cylinder. These builders, however, did not underrate the advantages offered by this new field, and the first of them to undertake the work was the Berlin-Anhaltische Maschinenbau-Gesellschaft, of Dessau, Germany, who in 1898 delivered to the Hoerder Mining and Smelting Co. a 600-HP., two-cycle, two-cylinder gas engine.

The excellent results obtained from this engine, coupled with the fact that the use of blast-furnace gases in gas engines is much safer than the burning of these gases under steam boilers and is also from three to four times as efficient, encouraged other iron works and a number of collieries to adopt gas engines for their work. The object of Mr. Reinhardt's paper on this subject is to review the extent of the application of gas engines in the iron works and collieries of Germany; the working results, including the influence of purification on the gases; and the present practice in the design of large gas engines in Germany. To ensure the conclusions arrived at being as correct and complete as possible, Mr. Reinhardt invited the iron works and collieries possessing gas engines to answer the following questions:

QUESTIONS ASKED OF LARGE GAS-ENGINE USERS.

How many gas engines have you at work, in course of erection, or on order? What type do they belong to? What size are they? What are they used to drive? What proportion of horse-power of the above are for continuous working, and how many are kept as reserve?

With what kind of gas are the engines worked—blast-furnace gas, coke-oven gas, or a mixture of both?

Is a gas-producer plant provided as a reserve?

How are the gases purified and cooled?

What power and how much water is employed for the purification of the gases consumed by the engine?

What proportion does this power bear to the power obtained from the purified gases?

What is the cost of purifying per cubic meter of gas?

What apparatus is employed to dry the gases after purification?

What is the percentage of dust contained in the gases before and after purification?

Are pressure regulators arranged in the gas main to the engines, and, if so, are they provided for each engine or for the whole installation?

What is the capacity of the pressure regulator?

What is the pressure of the gases before they reach the engine, and within what limits does it vary?

At what temperature and with what percentage of moisture in grams per cubic meter is the gas supplied to the engines?

After what period of working is a complete cleaning of the internal parts of the whole apparatus undertaken, and how long does this take?

Which parts require cleaning first of all, or more frequently than the rest, and how long does the cleaning of these parts take?

Do stoppages and troubles occur, and what are the causes of these: (a) broken springs? (b) hanging of the valves? (c) failing to start? (d) failure of ignition?

Have important parts of the machine already become defective, and how long after the first starting of the engine? What do you consider the causes: (a) cylinders? (b) cylinder covers? (c) pistons? (d) valve boxes? (e) piston rods?

How much water is used for cooling per horse-power and per hour: (a) for the cylinders? (b) for the pistons and rods?

At what pressure is the water used for cooling the pistons?

How much fresh oil is used per effective horse-power and per hour in the case of: (a) cylinder oil? (b) machine oil?

Has the consumption of gas by the engine been determined? If so, by what method, and what was it?

What sizes of units are, in your opinion, the most suitable for blowing engines and for driving dynamos?

Can alternating-current dynamos driven by gas engines be coupled in parallel without difficulty in your works?

INFORMATION OBTAINED FROM LARGE GAS-ENGINE USERS.

From the inquiries it was ascertained that:

the largest aggregate power of gas engines at a single works amounts to 35,000 Eff. HP. Sixteen works possess over 10,000 HP., and twenty-seven works possess over 5,000 HP. in actual working.

In most ironworks the whole of the gas engines work continuously without any reserve; a few have up to 40% reserve of gas engines, and a few have a similar reserve of older types of steam engines or steam turbines.

Nearly all engines in ironworks, naturally, work with blast-furnace gases. Two plants use only coke-oven gases, three use blast-furnace gas and coke-oven gas separately, and one plant uses the two gases mixed. One company utilizes the waste gases from the copper-smelting furnaces for driving gas engines. Producers employing coke as fuel are kept as a reserve at seven works. They are really only of use in case of a strike, to assure the working of the most necessary part of the plant.

The application of gas engines in collieries is much less important. This is due to the fact that the heat given off by the older type of coke-oven can only be utilized under steam boilers, and consequently, for these older plants, steam boilers are inevitable in collieries. Only the excess gas produced in the coke ovens is available, so that steam engines and gas engines will always be found in conjunction, and indeed in larger proportion as regards steam engines than is the case in ironworks. In the new regenerative coke ovens, the waste heat is utilized for pre-heating the oven itself, whereby there is an economy in gas, and a greater excess of gas is available for driving gas motors. The irregular production of gas can, however, only be considered available or free from drawbacks for motor driving when at least sixty coke ovens are in operation. The production of gas in coke ovens is much more irregular than in blast furnaces.

The aggregate power of all these engines was 30,300 Eff. HP. Of these twenty-four engines were already working at 15,600 Eff. HP., nearly all for the production of electricity.

The introduction of large gas engines in collieries was subsequent to their introduction into ironworks, and, therefore, only engines of comparatively modern construction are to be found. Exception must, however, be made in respect to the smaller motors, which were early employed in plants for the recovery of the by-products in coke-oven gas.

PRACTICAL EXPERIENCE OBTAINED IN WORKING.

PURIFICATION AND DRYING OF THE GAS.—Thorough purification and drying of the gas are believed to be the principal factors for continuous and undisturbed working of gas engines. German gas-engine builders have from the beginning considered the cleaning of the gas an essential condition. On the other hand, the Cockerill Company considered it unnecessary.

As a matter of fact, at many places Cockerill engines were working satisfactorily without any cleaning ... ever, while at other works this practice resulted in ... disagreeable experiences; in one case, owing to the ... cessive wear of the working surfaces of the cylin... and another time owing to premature ignition ca... by the formation of a crust, chiefly on the piston e... favored probably by excessive lubrication. If at ... works the engines gave satisfaction without the gas ... ing cleaned, and at another works similar engines w... unsatisfactory, this only proves that the gas conta... different percentages of dust at various works as it iss... from the furnace throat, and that it may become p... tially cleaned in the gas-main. It proves further t... the same quantity of dust does not everywhere ha... the same effect, since it may be composed, in so... works, of soft substances which do not so quickly ca... excessive wear of the working surfaces.

The methods of governing, and of mixing the gases ... newer constructions, in which more stringent specifica... tions for smaller variations of speed are laid down, are ... much more sensitive to the presence of dust, owing ... their being combined with springs as delicate as po... sible, in order to keep the resistance of the governo... and back-pressure upon it as low as possible.

Moist dust adheres with greater facility to the sur... faces with which it comes in contact than does dry dust, ... the greater part of which passes through the engine ... without being deposited. Great trouble is experienced ... with moist and dusty gas when the engine does not ... run continuously, but stops working on Sundays, for ... instance. It may then happen that the deposit of wet ... dust, which, while the engine is continuously working, ... does not offer very great resistance to the motion of the ... valve gear, dries to a hard crust while the engine is not ... running and causes these moving parts to become ... jammed, rendering the starting of the engine impossible.

In a standard type of purifying plant for blast-furnace gas, the gases on leaving the blast furnace are led through a series of so-called dry purifiers, thence through long pipe lines into the coolers or scrubbers, and from these into the so-called centrifugal purifiers (Theisen apparatus or fans with water spray). After leaving the purifying plant the purification of the gas should be complete, so that before being admitted into the engine the gas has only to be dried in filters or in capacious tanks. In several plants, by drying and by passing through a long main to the engine, a further purification of the gas takes place.

CONSTRUCTION AND OPERATION OF THE VARIOUS APPARATUS.

The dry purifiers consist generally of a combination of cylindrical vessels, in which the gas is led downward with a rapid motion and upward with a slow motion. During this movement, and especially during the change of direction of the stream of gas, the coarsest particles of dust are separated. The pipes leading from the above should be made as long as possible, with as large a section and as many sudden changes of direction as possible, in order that the gas may be further freed from coarse particles of dust.

The coolers or scrubbers are vessels in which the gas flows from the bottom to the top, and the water from the top to the bottom. The water must be finely sprayed to moisten the dust and thus increase its weight and cause it to settle to the bottom. At the same time the gas is cooled in the scrubbers in which the water vapors are condensed, and the dust is deposited.

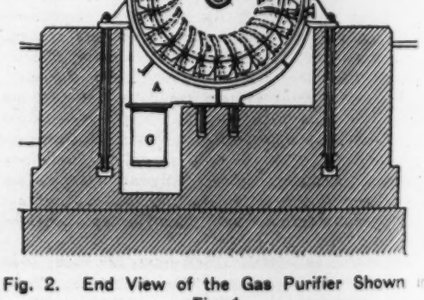

Fig. 2. End View of the Gas Purifier Shown in Fig. 1.

In centrifugal purifiers the further separation of the dust is effected by centrifugal action on the wet dust. The first centrifugal purifier in Germany was the Theisen apparatus, patented by Mr. Theisen, of Munich. It was subsequently discovered accidentally that an ordinary fan, with water injection, was also very efficacious for gas cleaning.

THE THEISEN APPARATUS.—The Theisen apparatus is shown in Figs. 1 and 2, and consists essentially of the

*Abstract of a paper read before the Iron and Steel Institute.

†Dortmund.

following parts: a suction chamber A, a pressure chamber B, a middle chamber C, drum D with shaft and bearings, and a grating E. Water enters tangentially to the casing of the middle chamber C, and leaves the apparatus through the pipe G.

After the gas has been cooled and charged with water vapor it is drawn in by the vanes h, and the coarse dust is separated in the suction chamber. Through the action of the fans at both ends of the drum D the gas is then blown through the space between the drum and the casing. The outer circumference of the drum is provided with a number of inclined spiral vanes i, so that

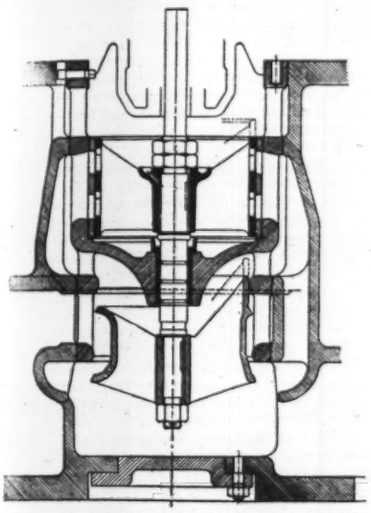

Fig. 3. A Balanced Double-Seated Valve Used on Large Gas Engines.

the gas has also to travel a long way in the form of a spiral. Hence, by injecting water at the same time a high degree of purification of the gas takes place, and the accompanying water vapor is simultaneously condensed. The dust is then projected against the spiral meshes of the coarse grating E fixed to the interior surface of the casing. By centrifugal action, the water entering in a tangential direction is at the same time distributed over the surface of the grating, which prevents it from becoming clogged and incrusted with the separated dust. In addition to this, the surface of the water is broken up, thus favoring cooling and condensation. This washing of the gas absorbs carbonic acid and sulphurous gases. The purified gas then enters the discharge chamber B, from which the water is thrown out by the vanes k, and the gas is forced to the engines with a pressure of from 50 to 100 mm. of water. The washer reduces the dust from 3 or 4 grams per cu. m. of gas to 0.02 or 0.03 gram with a consumption of 0.8 to 1.5 liters of water per cu. m.

Theisen imputes the useful action, during purification, in his washer to the steam present in the blast-furnace gas and to that formed by contact with the injected water, and on this account recommends his apparatus to be placed, not behind the scrubber, but without such apparatus by introducing simple gas pre-moisteners immediately behind the dry purifier, in order that the gas may be as hot as possible at the entrance into the apparatus. On the other hand, Professor Osann, in an exhaustive investigation of the purification of blast-furnace gases, chiefly by the action of cooling surfaces for the water vapors and the deposition of dust, considers it preferable to clean and cool the gases previous to their being introduced into the Theisen washer, so that the latter has only to remove the finer particles of dust which are otherwise difficult to separate. He hopes by this arrangement to effect a saving of power.

FANS.—The fans employed for the purification of the gases, as constructed by R. W. Dinnendahl at Steele, only differ from ordinary air fans in the construction of the vanes and bearings, which are of a much heavier construction to cope with the injection of water and the higher temperature of the gas. They are provided with a water inlet at the suction opening, and with an arrangement, as in disintegrators, for pulverizing the water, so that a sort of water curtain is formed through which the dust has to pass. The cohering particles of dust and water are separated by centrifugal action through which these particles are thrown against the inner circumference of the fan-casing. The under portion of the fan-casing opens into a tank, from which the separated slimes flow away and the purified gas escapes at the top outlet. The method of purification resembles that of the Theisen apparatus, except that in the former the passage for the opposing action of the gas and water is not so long. The usual sizes of gas-cleaning fans are from 15,000 to 70,000 cu. m. of gas per hr., requiring from 40 to 110 HP. For 1 cu. m. of gas from 1½ to 2 liters of water are required, and as a rule the dust is reduced to one-tenth of the percentage before washing.

When two or more fans are arranged parallel to one another for the purification of large quantities of gas, it is often difficult to obtain outputs equal in quantity and quality. It is therefore advisable to provide regulating dampers behind the fans, and, above all, to make the mains both before and after the branches to the fans, of large diameter so that they can at the same time act as air-vessels. As a certain preventive of the above difficulties, which are often of a very annoying character, the author suggests having the fans and the electric motors driving them running at the same speed so that their axes could be connected with friction-couplings and the fans produce equal differences of pressure.

THE BIAN COOLER.—This consists of a horizontal shaft turning within a cylindrical casing and carrying a number of disks of wire netting. The lower halves of the disks dip into water, and the gas passes through the meshes of the upper halves. The purification of the gas is continued in centrifugal apparatus until the desired degree of cleanliness is attained, after which it has only to be dried. This is effected by forcing the gas through a series of layers of wooden fiber or wool in large cylindrical casings, to which it yields its water. Naturally the resistance caused in passing through the layers of wool requires a large expenditure of power, and the renewal of the wet wool, together with the cost of attendance, necessitates the installation of a spare drier. Large vessels containing various materials through which the stream of gas is forced, with frequent changes of direction, are employed for the separation of the water, and these vessels are further aided by long pipes with frequent changes of direction. If a large gasholder is erected between the cleaning plant and the engines, in addition to its quality as a pressure regulator, it does excellent service in the separation of water, and renders the previous drying of the gas and the expenditure for attendance on the plant and power superfluous.

INFORMATION FROM THE QUESTIONS ON PURIFICATION.

From the inquiries sent to the large gas-engine users it was found that all smelting works among them have centrifugal apparatus in use for removing the fine dust; about half of them have scrubbers or Bian coolers with fans, and the rest scrubbers with Theisen apparatus, Theisen apparatus alone, or fans alone. From the nature of the information received from the ironworks it is not easy to reduce the respective merits of the various apparatus or processes to a common basis. The results obtained are therefore given as follows:

IRONWORKS.—The power expended in cleaning 1,000 cu. m. of gas per hr. varies mostly between 6 and 13 Eff. HP. Accordingly, the power thus expended varies from 1.8 to 4% of the power obtained by the purified gas. If the purification effected by the Theisen apparatus is compared with that by fans, it will be found that a single Theisen apparatus cleans better than a single fan, since with the former the proportion of cleaning is between 90 : 1 and 25 : 1, with about 6.5 Eff. HP. per 1,000 cu. m. of gas, and with a fan the proportion is about 12 : 1 and the average Eff. HP. 2.3. From two fans, one placed behind the other, a proportion of cleaning from 50 : 1 to 200 : 1, and power employed from 6.5 to 10 Eff. HP. per 1,000 cu. m. per hr. has been attained. Without taking the consumption of water into consideration, one Theisen apparatus is approximately equal to two fans.

With one exception all ironworks interviewed possess apparatus for drying the gas as described above.

In no case does the gas contain any suspended water—that is, no water above the quantity at the point of saturation at the corresponding temperature. This temperature is, in most cases, the same as the temperature of the air, or only a few degrees higher. In a few cases the percentage of water is even lower than that corresponding to the point of saturation at the temperature of the gas, but this is only possible when the water used for cooling is at a very low temperature and the gas is cooled to below the temperature of the gas arriving at the end of the gas main.

A further cooling of the gas would be of great utility, favoring the separation of water and purification, and thereby assuring the continual working of the gas engines without disturbance.

COLLIERIES.—The information received from the inquiries sent to collieries is not so complete as that received from the ironworks, owing to the collieries not having had as much experience.

Of fifteen collieries two had no special plant for the purification of the gas, but only plant for the recovery of the by-products; four collieries have plant for the separation of sulphur and tar; six a similar plant for sulphur only, and three a plant for tar only. The power expended is only that necessary to overcome the resistance of the gas passing through the purifier, which is on an average about ¼% of the power developed. The other working expenses consist only of the renewals of the filtering material, which amounts on an average to about 0.03 pfennig per cu. m., whilst the expenses of the purification plant itself increase greatly with the sulphur in the gas.

Only traces of tar have to be removed by the purifier, but it is equally important to remove the sulphur, which attacks the cylinders, piston rings, piston rods and stuffing boxes.

In one case it is stated that the percentage of sulphur was reduced from 5 grams to 0.7 gram per cu. m.

The heating value of coke-oven gas varies from 2,500 to 4,600 calories per cu. m.

The amount of gas available for gas engines also varies extraordinarily, ranging from 3¼ to 50%, according to the quality of the coal used, and above all according to the type of coke oven.

Engines using coke-oven gas require cleaning after similar periods to those using blast-furnace gas.

PRESENT DESIGN OF LARGE GAS ENGINES IN GERMANY.

From the answers received from the ironworks and collieries it may be concluded that double-acting four-cycle motors, mostly with tandem cylinders, are in keen competition with two-cycle motors, the single-acting four-cycle motors being no longer used.

VALVE GEAR.—A large number of gas engines have their valve gearing controlled by cams, and the action of the latter is smooth and unobjectionable. It is, of course, obvious that cams must be combined with stronger springs than is necessary with eccentrics, because with the former, in addition to the valve, spindle and roller lever, the driving rod of the gearing has also, as a rule, to be accelerated or moved by springs. In view of the satisfactory results of valve motions, whether controlled by cams or by eccentrics, no general decision can be taken as to which design is the better for all cases.

Fig. 3 shows a balanced double-seated valve designed by Mr. Richter for Thyssen & Co., Mulheim-Ruhr. Combined with it is a sliding sleeve on the same spindle, which, when the gas valve is shut, permits the admission of pure air to the inlet valve through a slit which is always open. If the gas valve is lifted, the sliding sleeve increases the area of the air passage regularly with the motion of the gas valve. The object of this valve gear is to obtain as regular an acceleration and retardation of the air and gas columns as possible, without the partial vacuum induced by an early cut-off being too high. Further, as the gas valve is double-seated, a good distribution of air and gas is obtained, and at the same time the acceleration of the air column is utilized to accelerate that of the gas column.

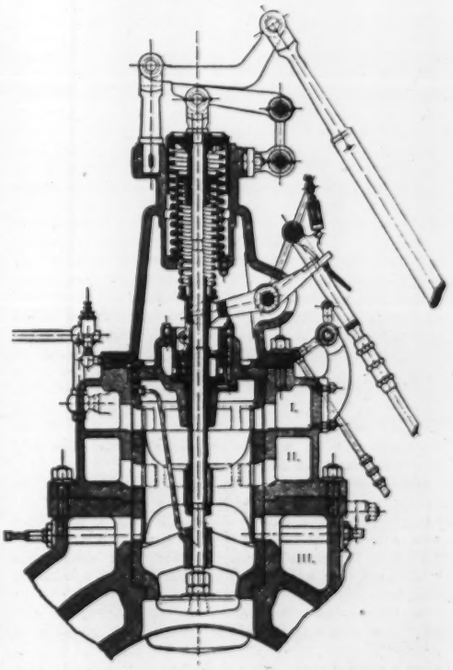

Fig. 4. A Gas Engine Governor for Working with a Constant Mixture and Constant Compression.

A governor for working with a constant mixture and constant compression has been patented by the author and constructed by Schüchtermann & Kremer. It is shown in Fig. 4. There are two separate air ports and a gas port leading into the cylinder space above the inlet valve. The inlet valve opens at the commencement of, and closes at the end of, the suction stroke. In the

cylinder chamber above the inlet valve, and independently of it, a slide moves so that it first closes the gas port I, and then one of the air ports II, while it allows the admission of pure air through the air port III, until, at a position of the piston depending on the load at that moment, it is suddenly disconnected from its outer mechanism. Its resulting rapid downward motion suddenly closes the air port III, and, at the same time, opens the air port II and the gas port I, so that air and gas enter for the mixture, both from rest. After the inlet valve is closed the slide again moves upward.

STUFFING BOXES, COOLED PISTONS AND PISTON RODS.—The stuffing-box packings generally permit a

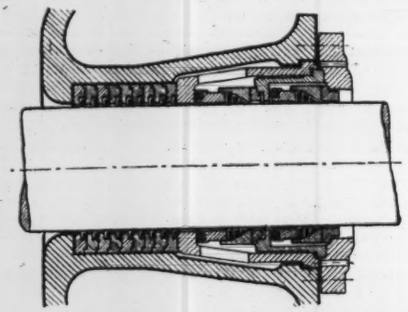

Fig. 5. A Stuffing Box Designed to Permit Easy Removal of the Packing for Cleaning.

movement of the packing rings in a direction perpendicular to the axis of the cylinder only, although in some cases a slightly inclined motion of the rod is allowed. Great care must be taken that the cylinder cover is well cooled, that the packing rings are well lubricated, and that they do not support the weight of the piston rod. These troubles might happen if the clearance between the packing rings and the stuffing box becomes filled with burnt residues, so it is necessary from time to time to remove the packing for cleaning, and for this reason it is advisable to make the stuffing box a separate and easily removable part as in Fig. 5, and not continuous with the cover.

Pistons cooled through hollow piston rods have proved very difficult to design. When they are divided into two parts, great attention must be given to the water-tight joint to prevent leakage of the cooling water, which is below 3 to 5 atmospheres, at the circumference of the piston, as even the smallest leakage prevents the formation of the electric spark necessary for ignition. The cooling of the piston rod and of the piston is now generally so arranged that the cooling water enters the rod at one end and flows out at the other. A flowing back is avoided by a pipe being fitted in the bore of the piston rod. In tandem engines this arrangement is either on each cylinder, or the cooling water is allowed to pass through both rods and both pistons, one after the other. In the first case the cooling water must be at a pressure of from 2½ to 3 atmospheres, and in the second from 4½ to 5 atmospheres. Concerning the manufacture of the piston rod, that system is naturally the best by which the axis of the piston rod, when erected and loaded with the pistons and the water they contain, is a straight line.

IGNITION AND STARTING.—A magneto-electric apparatus, driven by the engine, is generally employed for producing the electric spark to ignite the mixture at the end of the compression stroke. Frequently two igniters at each end of the cylinder are fitted to insure safety and rapidity of the ignition and combustion.

The rapid removal of plugs is important, because the presence of bad gas and the non-production of the spark are the principal causes, in modern engines, of a refusal to start; happily this does not often occur. If the magneto-electric apparatus is in good order, it is clearly indicated that the plug is covered with moisture, and hence no spark can be originated.

Dampness can be deposited during the night when the engine is not running, also when the admission and exhaust valves are open. In starting it may be condensed and settle from the compressed air used, if this contains moisture. In many plants the rule is to remove the plugs each time the engines are started, and thoroughly heat them.

To prevent water or moist compressed air being carried over from the air-holder, care must be taken to drain the latter, also to take the air from the highest point of the holder. Should ignition fail at one end of the cylinder while the engine is working, this requires the driver's special attention. This failure may be occasioned by a leakage of the cooling water from the piston, at a pressure of 3 to 5 atmospheres, by the partial fracture of the piston, of the walls of the cylinder, or of the cover. This water, leaking out during the suction period, squirts against the plugs on the return stroke of the piston.

In such cases, when the driver is convinced that the outer ignition apparatus is in good order, the engine must be stopped and the reason of the ignition failure ascertained; also if the load on the engine will allow of it being done, one end or one cylinder should be put out of service. If, however, they cannot be spared, the gas in the cylinder concerned must be shut off, and the compression working cut out, for instance, by wedging up the exhaust valve. If it is supposed that the piston is cracked, even though the leakage be very slight, the cylinder should only be kept at work in case of great necessity, because the presence of water in the cylinder quickly causes wear.

If precautions are taken to heat the ignition plugs before starting and to make sure that the gas is suitable and burning with a steady bluish flame, the starting of gas engines no longer offers the slightest difficulty. The pressure of the air employed ranges from 6 to 25 atmospheres. In most cases the valves work in the same cycle when starting as when running. The compressed air is admitted at what would usually be the commencement of the combustion stroke and gives the engine a start. The moment of admission of the compressed air should be determined in consideration of the fact that, in case of an ignition of the gases now drawn in, the combustion pressure attained is higher than that of the compressed air. Further, no such admission should take place before or during combustion, as it would deteriorate the mixture.

In multiple cylinder engines, particularly two-cycle engines, which can start with a corresponding small load, starting is often possible by admitting compressed air to one cylinder. In such cases ignition must be allowed to take place in the second cylinder, then the compressed air must be shut off in the first cylinder, and after a few revolutions, when the moisture originating from the compressed air has been evaporated by the heat developed by compression, the gas valve in the first cylinder must also be opened. In starting gas engines, the ignition mechanism must be so arranged that ignition of the mixture takes place at a time which corresponds to a smaller crank angle, distant from the dead center, than obtains at the regular speed. In the same manner the ignition must also be regulated by hand if the number of revolutions of the engine is variable, as is the case with gas blowers.

SIZE OF GAS ENGINES.—Most of the managers of ironworks appealed to answered the question as to the most practical size of the engines. For driving dynamos, 1,000 to 1,200 B. HP. per unit; for driving blowing cylinders for each blast furnace, a separate engine, usually, say, from 1,000 to 1,200 B. HP., or in some cases, larger units, say from 1,600 to 3,600 B. HP., according to the efficiency of the furnace. Concerning the size of the engines, it may be observed that with a few large units, as compared with a larger number of smaller units, the reserve power of the plant, also the safety of the apparatus, for example, of the pistons and cylinder covers, diminishes; and further, that the cleaning of the large engines is more complicated and takes more time. Units larger than 1,000 to 1,200 Eff. HP. are only to be found in very large plants, or where the space is limited.

From the answers received to the last question, concerning the possibility of connecting alternating-current dynamos in parallel when driven by gas engines, this, stated generally, can be done without special difficulty. From several sources it is gathered that sometimes the practice of switching in, at the moment that the engine is running without load, occasions difficulty; that naturally depends not only upon the degree of uniformity of the engine, on the momentum of oscillation of flywheel, and on the construction of the dynamo, but above all upon the action of the governor and the formation of the mixture at the time named, and for this reason will vary with the design of valve gear.

TWO-CYCLE OR DOUBLE-ACTING FOUR-CYCLE SYSTEM.—Many persons at the present time, in judging the question of systems, go so far as to prophesy that the gas engine will return to its original starting point, viz.: the four-cycle system, while others, equally convinced, affirm that the four-cycle system will not continue to be adopted by ironworks and other manufactories. Even with the experience gained up to the present time, it is impossible to give an opinion, based upon sufficiently trustworthy evidence, in favor of either of these opposing views. It is impossible to come to a conclusion, from the total horse-power; for up to March of this year engines with 260,000 B. HP. were at work, or on order, for double-acting four-cycle, as against 91,000 for two-cycle, without further considering the proportionate value of the two systems. If these figures prove that the competition of the two-cycle engine must not be neglected, on the other hand the importance and connection of the builders of the four-cycle types must be considered advantageous to the latter.

The builders of two-cycle engines will themselves admit that these motors are less adapted for the high speeds required for driving dynamos than for driving blowing engines and pumps, because, with a reduced time of charging, the resistance of the charging pump cannot be kept low enough. Also, owing to the relatively larger number of explosions, especially with gases of high calorific value, such as coke-oven gas, the occurrence of premature ignitions creates uncertainty. Moreover, the governing hitherto employed in two-cycle engines for dynamo driving is, as a rule, inferior to that of four-cycle engines. For this reason it may be explained that several firms who build two-cycle engines have lately decided to adopt also the manufacture of double-acting four-cycle engines.

On the other hand, the two-cycle engine is, without any doubt, most suitable for driving blowing cylinders; for, as already stated, it permits, within wide limits, a variation in the number of revolutions per minute; it starts easily against a load, and at the low speeds of the blowing piston the work of the charging pump is not excessive. Klein Brothers, for instance, state that the work of their charging pump with valves is from 6 to 7% of the work of the power cylinder, so the difference, compared with the negative work of the four-cycle motor, no longer preponderates.

Theoretical discussions concerning the correct or the incorrect mechanical efficiency, which during the last year created such a stir in Germany, can for the present contribute nothing to elucidate the question of the systems. The managers of works, in addition to inquiring about the price and power of a gas engine, above all inquire about the security in working, and least of all about the quantity of gas consumed per brake horse-power. They do not trouble themselves at all about the mechanical efficiency.

Suitable trials concerning the consumption of gas in more recent engines are not available for comparison, therefore it is not known how far the two-cycle engine is at the present time, in this respect, inferior to the four-cycle engine. Should the ironworks now be compelled to consider an economy of gas, the author does not believe that the larger consumption of the two-cycle engines would for long have any great influence on the question of systems; for then the ironworks would probably first consider a more thorough cleaning of the gas employed for heating the blast and for burning under the boilers, thereby increasing its value, and in this manner saving gas. So long as these conditions remain as they are, and so long as the four-cycle engine is not more secure, under average working conditions, than the two-cycle engine, so long will the question of systems not be decided by general and theoretical considerations, but by the ironworks and mining industries themselves.

CONCLUSION.

The present attitude held by the managers of German ironworks with regard to the application of gas engines shows the great value they attribute to the utilization of the waste gases of their furnaces, and the successful efforts made by German engineers to meet the requirements suddenly demanded by the ironworks. Incidentally, it also shows that German ironworks are obliged to utilize to the uttermost the sources of power at hand in order for them to exist and participate in the trade of the markets of the world.

THE CARE OF LOCOMOTIVE BOILERS AT TERMINALS AND WHILE IN SERVICE.*

In order to learn which of the methods [of caring for boilers] most commonly used approach nearest the ideal, and at the same time held the engine out of service the least time, the following questions were sent out:

(1) Average number of miles per locomotive per month, freight and passenger. The object in asking this question was to obtain data for calculating the earning capacity of the locomotive and to determine the probable loss in mileage due to engine being held for washing the boiler.

The replies received varied all the way from 2,200 to 5,300 miles for freight and from 3,000 to 9,500 for passenger engines. The high mileage was invariably on roads having good water.

(2) Average miles between washouts? From 500 to 50,000.

(3) Average time consumed washing boilers? Two to ten hours. Personally I do not think the two-hour man did a good job.

(4) Average cost of washout? 37 cts. to $8.50.

(5) Average life of fire-box? Of flues? From two years to twenty for fire-box and from six months to ten years for tubes.

(6) Method used in cooling down and washing boiler? From no particular method to the ideal way of slow cooling and washing and filling with hot water.

(7) Are boilers washed regularly, etc.? Some do, others do not.

(8) Have you used soda ash or other chemicals in feed-water? If so, with what results?

*Condensed from Report by F. P. Roesch, Chairman Committee on Care of Locomotive Boilers, submitted at the annual meeting of the Traveling Engineers' Association, Chicago, August, 1906.

To this question several replies were received, but the reply received from Mr. J. F. Roddy, of the Santa Fe [to this and the other questions asked—Ed.] is in itself such an excellent treatise on the care of locomotive boilers and contains so many other valuable features and pertinent remarks that it is given in full [condensed here].

EXPERIENCE ON THE SANTE FE.

Sir: With the able assistance of our General Boiler Inspector, Mr. George Austin, I submit the following in answer to the list of questions relative to the care of locomotive boilers at terminals and while in service.

(1) Average number of miles per locomotive per month —freight service, 3,000; passenger service, 5,000.

(2) Average miles between washouts—Cannot give you anything definite. Governed by service and water conditions.

(3) Average time consumed from time engine arrived at cinder pit to time engine is again ready for service after being washed out, seven hours.

(4) Average cost of washout, 70 cts.

(5 and 6) Average life of fire-box—Cannot give you anything definite, as owing to water treatment the life of fire-boxes is being extended so that it is impossible at this time to give definite information. Average life of set of tubes—Passenger service, eighteen months to two years; freight service, twelve to eighteen months. This varies according to the different divisions and service. The water treatment has also introduced in the case of the flues a question as to the average life, it having prolonged the period of successful service of the flues to such an extent that I cannot give more definite information at this time.

(7) Boilers are washed regularly, and a record of each washing and place at which washed, together with the name of the boiler washer, is placed on a card and placed in the cab.

We are treating water in track tanks with soda-ash and lime, this treatment being directly under the supervision of our Chief Chemist, Mr. Powers, who is the originator of the system of treated water now in use on the Santa Fe. The average life of flues before water treating was six months, and many failures occurred during that time. I will here state that during the year 1905 we had three months without a failure from leaky flues on the Middle Division of this system, which seems remarkable, compared with the average performance previous to water treatment, where in many cases the number of flue leaks would aggregate from forty to fifty. We are now running our flues in passenger service eighteen months to two years, and in freight service twelve to eighteen months, with at least one-tenth the failures we had previous to water treating. Our side-sheets have stopped cracking and corrugating. Stay-bolts have ceased leaking, i. e., to the extent of being a serious proposition. Very few half side-sheets are applied—in fact, so far as injury to fire-boxes is concerned there is nothing in comparison to conditions that prevailed previous to water treating.

The prominent feature of water treating which is considered an adverse feature, is the increased foaming. This is being met by judicious use of blow-off cocks and the use of Dearborn boiler compound.

We explain to our men that the water in a boiler that is foaming is concentrated to about 200 grains of alkali to the gallon, and when foaming begins it is impossible to stop it until this concentration has been reduced below the foaming point. This can only be done by blowing out or working out through the engine a quantity of water and replacing it with sufficient clean water to bring the average concentration below the foaming point, then the foaming will cease.

While it may look like a step backward, it is the opinion of the writer that a surface cock, coupled to a perforated pipe in the boiler, conveniently located above the crown sheet, and to be used as an auxiliary to a blow-off cock located at the lowef part of the back head, would materially assist in overcoming the foaming condition, and would be the best possible location for these devices, the surface cock to be used only when not much sludge is present, it being understood that the water is concentrated, so far as foaming matter is concerned, heavier at the top than it is at the bottom. This is explained by the fact that the water being put in by the injectors, being of a lower temperature, goes to the bottom, and is, except for the sludge, so far as foaming matter is concerned, purer than the water above. It would seem then logical, in view of the above conditions, that blowing out from the surface would get out the most foaming matter, and we are all familiar with the fact that in alkali waters that carry other solids, the top water in the glass frequently shows the presence of large quantities of solids, which appear to be floating on the surface, and which the surface blow-off cock would remove. It would enable you to retain your fresh water in the boiler while overcoming a foaming condition, while on the other hand, to overcome a foaming condition with the blow-off cock at the mud ring you would necessarily have to blow out a large amount of fresh water that had just been applied. The writer has had considerable experience with the surface blow-off cock, and with very satisfactory results.

Our aim is to keep the blow-off cocks in first-class working condition, and with a good working blow-off cock he is a very poor engineer who makes a failure on account of foaming or works the foaming water through the engine—that is to say, with ordinary water conditions. Our conditions as to foaming are showing steady improvement as our men become educated in the use of the blow-off cock. We have men who will run 1,600 miles without asking for a washout, and more are slowly falling into line; while others in the same service with the same class of engine want a washout or water changed each trip. This is self-explanatory—one man is interested and an engineer; the other is neither.

Another fact in connection with the foaming proposition in my experience on this railroad, and one worthy of consideration, and which is borne out by our records, is that we had just as much foaming previous to water treatment as now, had just as many failures, and the work the engines were required to do was not nearly as heavy as at present. But before water treating the boiler washer was blamed for foaming; now it is the soda ash.

Speaking of boiler washing, I will say here that previous to water treating we washed boilers frequently to get rid of scale, an impossible proposition, as evidenced at that time by leaky fire-boxes and flues. Now, washing out is an easy proposition—some sludge and a little scale. The scale now does very little injury, as compared with what it did before water treatment. We get our boilers clean now in a few minutes' washing, while previous to water-treating there was no such a thing as a clean boiler that had been in service three months.

We first began treating water on the Santa Fe system about three years ago. We have now in operation on the Eastern Grand Division, which includes the territory between Chicago and Purcell, Ind. T., 34 treating plants, and these plants, as before stated, are under the immediate charge of the Chief Chemist, Mr. Powers, who gets a sample of the waters treated each week, and which are analyzed, and treatment varied accordingly. These treating plants are divided into districts and each district has an assistant chemist in charge, who makes two or three visits each week to each plant, keeping close check on the conduct of each treating station. I understand that Mr. Powers treats the water at an expense of about 3 cts. per 1,000 gals.

The kind of blow-off cock in use on the Santa Fe Railway is a gate valve, operated with levers conveniently arranged to be operated by hand. This is another proposition we are improving on. We are trying to get these devices arranged as conveniently as possible for the enginemen to work, and pipe them so that the proximity of cars or buildings or the direction of the wind will not interfere with their operation, whether the engine is moving or not. Our blow-off cocks are usually located near the mud ring, at front and back end of fire-box, in the side sheets. From our earliest recollection it has been the custom of engine builders to apply blow-off cocks. These have been applied more for the convenience of boiler washers than for any assistance they might be to the enginemen while on the road. Such being the case, but little care has been given as to the location of the cocks or of the operating devices. As we gain in experience in our knowledge of the benefits of blowing out, conditions are changing. It is now being realized that the blow-off cock, properly located and conveniently arranged for working, is one of the most useful devices we have on the modern engine.

The proper use of the injector is an important factor in the care of locomotive boilers. It is common practice at roundhouses to set out engines with a heavy fire in them and fill the boiler full of water, before or after setting out, to prevent popping off. The particular adverse feature of this plan, and which I particularly desire to explain, is that when water is put into a boiler while the engine is standing, the only reduction made in the steam pressure is the quantity of steam used to operate the injector during the process.

The care of the boiler, both on the road and at terminals, simply means the application of common sense, and that each one having in charge or the direction of the care of these boilers shall understand a few simple propositions. The boilermaker should see to it that his flues are tight and clean, not with that degree of tightness that is frequently allowed to be let go with the understanding that it will take up when hot, but that the flues must be absolutely tight—not a sign of a leak from them. That the grates shall be in free working condition. That the blow-off cocks and injectors shall be in good order and conveniently located. The engine crew should understand that the preservation of the efficiency of the boiler depends largely on two propositions:

(1) Pressure should be carried as nearly uniform as practicable; even temperature by careful firing and use of injectors.

(2) Keep the boiler as clean as possible by free use of blow-off cocks.

The engineer with average good flues and other good conditions mentioned and following out suggestions as to equal temperature and keeping boiler clean, will seldom fail to give good results from his handling, and it must be a source of satisfaction to those who send out engines in that condition to have performances that will compare with any performance on any railroad so far as successful operation of power and prevention of engine failures is concerned.

Yours truly,

J. F. Roddy, Road Foreman of Engines.

SUMMARY OF REPLIES RESUMED.

(9) What experience with Kennicott Water Softener?

(10) What kind of blow-off cocks, etc?

(11) Have you had any experience with Talmage device or Talmage system of cleaning boilers, etc.?

The ninth and eleventh questions were asked to bring out arguments for or against chemical or mechanical treatment of water. Replies to ninth question were: No railway replying was using the system at all tanks, consequently none were in position to give definite data; where it was used, however, all reports were in favor of it, as by this system of purifying the water the life of the boiler tubes was increased 30%, while failures due to leakage were reduced in like ratio. One strong argument in favor of the Kennicott system was that it required little, if any, care; all that was necessary was to install the plant and have an intelligent man look after it. It is to be regretted that no more full and definite information in regard to this system was brought out.

To the question in regard to blow-off cocks, replies were received showing that every known blow-off cock from the old plug to the most elaborate automatic is in use. It is apparent from these replies that mechanical men do not realize the important part played by the blow-off cock in the care of the boiler. The blow-off cock is half the battle. What we need first of all in the proper care of boilers is a first-class, reliable blow-off cock—one that opens easily and is seated by pressure in the boiler; one that is not continually leaking, and having removable seats that can be renewed with little trouble and less expense; one that the engineer is not afraid to open on the road, as he knows he can depend upon it. He cannot afford to take chances with an unreliable article and will not do it; therefore, if you are dependent upon your engineers for blowing out boilers on the road, give them a good blow-off cock if you expect them to use it.

To the eleventh question but four replies were received, all, however, highly favorable toward the Talmage system. The following is a brief synopsis: Miles between washouts with Talmage system, 5,000; without, 800. Cost and duration of washouts, same with or without. Life of tubes with Talmage system increased 35%. Engine failures and boiler repairs decreased 58%. Earning capacity of locomotive increased where engines are pooled, 22%; where not pooled, 8%. Foaming and priming entirely eliminated, regardless of the kind of water used. Cost of original installation, if increased earning capacity is taken into consideration, saved in 30 to 60 days. Cost of operation about 22 cts. per hundred miles. Maintenance cost, practically nil.

As all may not be familiar with this system, a brief description may be in order. The Talmage system of caring for boilers is entirely mechanical. It consists, first, of a series of perforated pipes placed in the belly of the boiler, over the crown-sheet, and in the leg, about 8 ins. above the mud ring. Each pipe is connected to a blow-off cock which is seated by the pressure in the boiler. On the boiler-head is placed a large sight-feed lubricator holding about 1½ gals. of oil. This lubricator is tapped into the boiler-head below the water level and the oil (a special distillate called Rubra oil) is fed directly into the water, mixing with it, and precipitating the solids to the bottom in the form of oily mud. So well does the oil perform its work that flues after one year's service have a coating of scale not much thicker than ordinary writing paper. All the mud collected in the boiler is blown out at the end of each trip through the blow-off cocks. The boiler is washed out once in 20 or 30 days. On one road, with which I was connected, where this system was in use, the engines so equipped were run 5,000 miles between washouts, while those not equipped were washed every 700 miles. When it comes to care of locomotive boilers in service and at terminals, I know of no other method that will come nearer combining the good features of the ideal and at the same time eliminating the objectionable features, than the Talmage system.

ELECTRIC HEATING for residences was discussed in a paper read before the Atlantic City Convention of the National Electric Light Association by Mr. James I. Ayer. He states that in cooking, gas at $1 per 1,000 cu. ft. is equivalent to electricity at 2½ cts. per KW. hr., and that while electric cooking is practical at a higher rate, it will demand a 5 to 3-ct. rate to make it an important competitor of gas. A 10-gal. jacketed hot-water boiler can be heated to 150° F. with approximately 2½ KW. hrs. Radiators for occasional use in common-sized bedrooms should have at least a capacity of 1 KW., while for heating a bathroom a heater of at least 2 KW. should be used in order to heat the room quickly, say 15 to 20 minutes. The cost of doing the average family ironing with an electric iron is given at $1 to $1.25. Instantaneous hot-water heaters are not recommended, although for small quantities of water the cost of operation is not excessive.

The cost for heating one gallon of water to different temperatures at different rates is given in the accompanying table, the initial temperature being 60° F. and the efficiency of apparatus 85%:

Total	Watts used for—				Cost in cts. with current at			
Temperature.	5m.	10m.	20m.	1 hr.	3c.	5c.	10c.	20c.
100°.....	1296	648	324	108	.32	.544	1.088	2.17
150°.....	2976	1488	744	48	.74	1.24	2.48	4.96
175°.....	3744	1872	936	312	.94	1.56	3.12	6.24
200°.....	4608	2304	1152	384	1.15	1.92	3.84	7.68
212°.....	4992	2496	1248	416	1.25	2.08	4.16	8.32

SOUND ENGINEERING IN INTERURBAN RAILWAY CONSTRUCTION.*

By Guy Morrison Walker.†

In the construction of railways there is a constant conflict between two diametrically opposing views. First, there is the view of the engineer whose scientific and technical education leads him to plan and urge the best that money can buy or produce; regarding the proposition as an opportunity to show his engineering skill. He struggles for long tangents, low grades, heavy bridges, wide cuts and fills, and a surplus of motive power, constantly holding up to view the desirability of securing economy of operation and low cost of maintenance. On the other hand stands the promoter or broker, who, ignoring all these physical problems, tries to see how much paper in the shape of bonds and stocks he can issue and float against the least possible real property.

A story related of the late Senator Brice is appropriate because it particularly illustrates these divergent points of view. It is related that on one occasion the Senator called upon his engineers for plans and specifications for a proposed road. When the plans were completed and handed to him he sat down to look them over. After he had completed his examination of them he sent for his chief engineer and upon the latter's appearance, the Senator turned upon him and indignantly demanded, "What do you think this road is being built for?" to which the engineer replied, "Why, to carry passengers and freight, of course." The Senator retorted, "Well, it isn't! It is being built to carry bonds."

Now, the fact is that neither point of view is the correct one, but that somewhere between these two extremes lies the true economic means of a road good enough to carry the traffic and business in its territory, with enough stocks and bonds issued against it to recoup the bankers and investors for their outlay.

The first engineers on interurban railways came from the city lines, and with their city experience they imposed upon these interurban roads city construction and supplied them with city power, as if for city traffic, burdening them not only with a heavy fixed charge to cover the abnormal capital expenditure, but with the expense of a general organization like that on city lines. One of the first interurban roads that I ever saw was laid with 90-lb. girder rail along the side of a public highway, and this was not changed until the road had been compelled to pay some fifteen death claims growing out of this foolish construction. Another road that I know of, with less than twenty miles of track, had a president, a general manager, a superintendent, a chief engineer, an assistant engineer, a chief electrician, an assistant electrician, a treasurer, an auditor, a traffic manager, a claim agent and a road master; all these to look after the business developed by three cars furnishing an hourly service in each direction over the road.

It was only the fact that these interurban roads were built in thickly populated communities that enabled most of them to carry this burden and survive the management that they endured. Few of them proved profitable until, as years rolled on, the farms through which they ran were cut up into small plots, the communities filled up with new population, and the traffic developed to the point where it was able to absorb this early waste.

When interurban railways first began to be built, there were many places where the population was already so dense and well distributed as to furnish the traffic necessary to make such roads pay, but the ten short years that have elapsed since interurban electric railways were first proved to be successful, have sufficed to see almost every locality with traffic and population enough to support an interurban railway, already supplied with such a service. Indeed, reckless promoters and ignorant investors have built many such lines in communities not yet sufficently developed to support them, and now find that they have an investment which not only yields them no income, but that the traffic in many instances does not yield enough to pay even operating expenses, and so they are threatened with the loss of their principal, and the fault in many of these cases has been due to the short-sightedness and stupidity of the engineers in charge of the construction.

There is a strong disposition on the part of most engineers to spend on the construction of a road all the money that they can get their backers or clients to put up. As an illustration of this I can cite the case of a small road only seventeen miles in length running from a city with 150,000 population to a city of about 10,000, the smaller city also having an excellent lake resort. The gentlemen backing the enterprise were bankers and conservative business men of large means who solemnly determined that in the case of their road there should be none of that waste and expense incurred by penniless promoters who have to resort to all sorts of plans to finance their schemes. These worthy men knew that some of their friends had made a large amount of money in interurban railroads, and they decided to go into the business for themselves, but as none of them were railroad men, they determined to get what they believed to be the best expert advice obtainable on the subject, and so employed one of the leading firms of electric railroad engineers in the country. They had heard that a good interurban railway could be built and equipped for an aggregate sum of $25,000 a mile, and they explained to the engineers that the smaller city before mentioned was about half way between the larger city and the terminus of another road, and that they desired also to build this link of 39 or 40 miles, and that they had raised among themselves a fund of one million dollars. They explained to these engineers that they desired a good road, and that with cash on hand they wished the benefit of every economy that could be secured by paying cash for everything, but that, as they were without railroad experience, they should depend upon and be guided by the advice of these engineers.

At the time that I was called upon to investigate the situation the engineers had completed the 17 miles of road from the large city to the small one, leaving 22 miles yet to build in order to reach the terminus of the other road. The construction work so far as it had gone, was excellent. The road had been built in perfect line and absolutely without grade except for an undergrade crossing of a steam railroad. It was laid with 80-lb. steel rail on cedar ties, laid 3,000 to the mile, with 3 ft. of crushed stone ballast under the ties. The poles were trimmed octagonally, heavily painted, and set in concrete bases and so perfect was the alinement of the poles and overhead brackets that the last pole and the last bracket shut out from sight all others. The cars were splendid Pullman coaches 56 ft. in length over all, equipped with four 75 HP. motors and weighing almost 40 tons apiece. The power-house was a magnificent structure containing excellent general offices, and built to hold two complete units, each of which was designed to operate the entire 40 miles of road, though only one unit had been installed. The whole property was altogether the finest and most perfect of interurban railroad construction completed in this country up to that time.

But the trouble was that at this point the bankers who had been footing the bills found that the entire million dollars that they had raised had been expended, and as their funds were exhausted, construction work was forced to stop, even though they had less than half as much road as they had expected. The property, however, that had been built, was a monument of engineering skill, and the engineering firm which built it took such pride in it that they made a practice of taking prospective clients out to see this road as an exhibit of the kind of work that they did. Now persons contemplating the construction of such roads usually make it a point to see and have an interview with the owners of such a property, and the gentlemen owning this road which had cost them so much more than they had expected it to cost, had no choice but to begin operating the mileage already built while looking for a way out of their trouble. The first year of operation the road took in $40,000 gross, every dollar of which was eaten up in operation, so that their loss for the year amounted to $50,000, or the interest on the million dollars that they had invested. With no net earnings it was impossible for them to sell their bonds. Their capital was tied up, and although every man in this group was active, they were unable to consider any new enterprise. The second year of operation produced $49,000 gross earnings, while the cost of operation was reduced to $38,000, making net earnings of $11,000, or a little over one per cent. on their investment. But the third year they induced some friends to join them in building the link of 22 miles necessary to connect their property with the other railroad. The construction of this link brought to their road the business of a city of 300,000, and nearly doubled the traffic and receipts of their first mileage, yet it was not until the fifth year, after a consolidation of their original mileage with the newly built link, that they were able to sell $800,000 of bonds on their property and so get back some of their capital that had been tied up for so long.

As a consequence of the experience of these gentlemen, the engineers who built the road sustained a long series of disappointments, for as a rule the prospective clients, after having seen the owners of this wonderful property, went on their way with the joy of men who have narrowly escaped a great catastrophe, while to this day the mere mention that this distinguished firm of engineers has anything to do with a proposition, is enough to make it unattractive to any banker or investor in the States in which this property is well known.

It is really a great temptation to see how fine and perfect a property you can build when you can find some good fellow to put up the price, but I have described the foregoing case to you at length in the hope that the experience of these well-known engineers may serve as a warning to you. Build no monuments of engineering skill; monuments are expensive, especially for the party who has to pay for them, and you will usually find that they mark the finish of many an otherwise successful career. You must remember that primarily a railroad is an economic machine intended to build up a community by making a market for its products and by inducing emigration into it, but to accomplish its purpose its rates must remain as low as possible and not be above normal, and that ultimately the territory served by it must pay the cost of securing such service.

Thus you can easily see how a road too well and too expensively built may for a long time be a drain upon the community and really retard growth where it was intended to build up. Even at the present time the most serious handicap upon existing roads and the most serious obstacle to the further development of interurban railways is the heavy construction advised by most engineers and the heavy equipment almost universally recommended by manufacturers.

The promoters and owners of these properties have not generally taken the public into their confidence, and so it is only those who are on the inside and to whom come the frequent appeals for financial assistance, who know the old, old story of elaborate construction, built at tremendous cost, and heavy equipment run at enormous expense, in advance of the development of traffic. Many of these roads have struggled along borrowing the money with which to pay fixed charges and striving to keep out of the hands of a receiver for a year or two longer, in the hope that by that time the traffic will have developed enough to enable them to pay their way.

It is impossible to estimate how much the development of interurban railways has been retarded by these false standards of physical perfection, and the time has come when the interest and rights of bankers and investors whose capital has been tied up in unremunerative projects, are entitled to paramount consideration, and I wish to impress upon you that, as engineers, you have no more right to experiment at the expense of your clients in an undertaking which they expect to be remunerative, than has a physician to take liberties with the body of his patient.

Select equipment that you know will do the work. Be neither the first to adopt a new device, nor the last to abandon an old. It is your duty as engineers to consider first the economic feature of the enterprises submitted to you for your decision or direction. It has been said that there are no physical difficulties with which engineering skill cannot successfully cope. It is merely a question of money. Practically speaking, this is true, and you will find early in your careers that the real question that you have to answer will not be "can it be done," or "how shall it be done," but a really far more important question as to whether the results to be secured will warrant the cost. You should strive to make money for your clients, for by so doing you will not only secure a satisfied clientage, but by building for them profitable and paying plants you will place it within their power to proceed with the building and development of other properties, and so add to the prosperity of the community while making business for yourselves. On the other hand, if you tie up the capital of your client in an unprofitable proposition, you are guilty of an economic crime against the community in which the non-paying investment is made, and you commit a wrong against the man whose further activities you have prevented by placing his capital where he is unable to realize upon it, in addition to losing a client and destroying business for yourselves. A large fee will be cheerfully paid from a successful enterprise out of the operation of which all the stockholders are profiting, while a pittance will be paid grudgingly out of a wreck.

And so, instead of the old standards that have so long prevailed, I desire to raise a new and practical standard which recognizes not only the rights of the investor but the economic good of the community in which the investment is made, and so I say to you, "Build not the best, but build the best that will pay."

It is plain that railroads built according to the standards of construction that prevail in communities thickly populated and with a heavy traffic already developed, will not pay for years to come in these thinner populated regions, and because the engineer has not yet been found to construct a road as cheaply as it must needs be constructed for it to pay in such localities. And so further development of interurban railways has lately come to be a question as to whether or not a locality must do without local service because a road costing $40,000 a mile will not pay in that territory, or because it cannot support a road costing say over $20,000 per mile.

In considering a new proposition you should first determine what investment the territory will support. Be

*Extract from an address before the students of Sibley College, Cornell University.

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assured that the necessary capital is in sight and then plan a completed and earning plant to come within the limits of the proposed investment. It is one of the most common complaints against engineers that the completion of their plans usually cost 50% more than their estimates. As a rule there is nothing so worthless as the "engineers' reports," which the promoters lay before bankers and financiers, unless it be the franchises of which they talk so glibly and for which they claim to have expended such large sums. After the surveys necessary to locate the line, which should not cost much, the first expenditure of money should be for the securing of all the right-of-way that can be secured without condemnation proceedings, and then suit should be at once instituted against these. The reason for this is, that if an enterprise has any merit in it whatever its success is assured from the time that it owns a continuous strip of right-of-way between the proposed terminals, while if it has no merit there is no expenditure that involves less loss, for the fact is that the importance of transportation is so great that there are few real estate holdings that appreciate in value as do these comparatively worthless small tracts when strung together in a continuous line from city to city.

The right-of-way secured, the next money expended should be for grading. There are two or three good reasons for advising this as the second step. The first is, that there is nothing in connection with railroad work on which you can make a larger and better showing with such a small expenditure of money, as you can in the matter of grading. Then, too, it satisfies your client, for he is able to see results; it satisfies the community, for they realize that work is being done and that a railroad is being built, and nothing goes farther than this in establishing credit for the new enterprise; while most important of all, the possession of a graded right-of-way is the best insurance of your client against competition or loss, for even if his funds should fail him at this point, it is more than likely that he will be able to turn such an asset into some new company for a profit.

Having gotten thus far, the next step is the purchase of ties and rails, and then with the least expenditure possible on any other account, hurry the laying of track until you can show a continuous pair of rails between your terminals. So many engineers make the mistake of practically completing their track as they go, expending as much in the completion of ten miles, which leads them only half way to the objective point, as would be necessary to reach the objective point if the wiser course had been pursued. The ten miles of track will take you nowhere, but you can ride over the twenty miles from one town to the next even though the going may be rough and slow.

Up to this point you will have been producing real property with the least possible waste. The difference between the 60-lb. and 80-lb. rail will enable you to save 25% on the investment in steel, and I might say that one of the best interurban roads of which I have any knowledge has been running its cars for nearly twelve years over 50-lb. rail that is still without sign of wear or deterioration.

Whatever you use, rail and ties should be the best in quality, for there are no profitable economies in the manner of permanent way, but from this point on you should carefully determine the best that the immediate traffic will support with the least probable loss on account of future replacements, and it will not do to discount the future too much. So many engineers burden a small proposition by attempting to build along with the first mileage a power plant large enough not only for the original proposition, but for all its probable extensions. Now, it is mileage that earns the money, and to burden a small proposition with the capital charge of a heavy power house for which it has no use, simply means to break it financially.

The proper plan is to install units, second hand if possible, no larger than the existing mileage needs for its operation, installing additional units as fast as its growth and extension may make necessary, until the territory has been reasonably covered, and the traffic developed to the point where the mileage can properly use and the earnings carry, the cost of a suitable power-house, for when this time comes, the original units are not loss, but may be reinstalled in other places to carry other plants through a similar period of development. There is no other initial economy that pays as this does, for it is rarely possible to anticipate the power demands of a territory, and great loss has frequently been incurred by attempting to do so.

One of the most foolish extravagances is the building of a double-track road where a single track will carry all the traffic that can be developed for years to come, for with your right-of-way and grade, it is a simple matter to supply the second track when the traffic becomes too heavy for the first. So, if you really must have 50 miles of track, and the distance is only 25 miles, find some other place to build the other 25 miles, for it is far better to have two single-track roads paying big dividends, than a fine double-track proposition that does not earn its fixed charges.

Probably more important even than the question of power is the question of cars and equipment. Cars of from 60 to 70 ft. in length, equipped with four motors of from 75 to 100 HP. each, look very handsome and start up quickly from zero, but they cost about $10,000 apiece, and the amount of power that it takes to move the mere weight of the car is a matter that deserves consideration. One of the best-paying properties that I know has for years used a car with 56 seats, measuring 42 ft. over all, equipped with only two 35-HP. motors. These cars are built with firm steel frames, yet are extremely light, and have cost complete, but little over $4,000 apiece, yet they take in just as much money as any of the large cars.

It is in this matter of traffic that engineers are more often astray than in anything else, for their desire to make new business too frequently induces them to make estimates not only unsupported by any experience, but in many cases beyond all reason. A recent very glaring instance of this kind has come to my attention where a distinguished firm of engineers, in order to justify the expenditure made necessary by some very heavy construction, and a large amount of difficult bridging, estimated the traffic on a 50-mile road between two large cities at a higher amount per mile than the street railway mileage in those cities had ever taken in, while the fact was that the gross earnings of the road would hardly have been sufficient to pay the fixed charges on its proposed cost.

Two interurban roads running out of Cleveland, Ohio, have 40 and 44 miles of track, respectively. The 40-mile road serves about 440,000 people, while the 44-mile road serves about 420,000 people, or only 20,000 less than the first road. With a population so nearly the same the engineers had estimated that the traffic of the second road would be approximately the same as that of the first, but after several years of operation the traffic receipts of the shorter road are still twice as large as those of the longer road, which has now been in the hands of a receiver for several years. The reason for this difference in earnings was, however, understood when upon investigation it was found that 400,000 of the population estimated to be served by each road was in the city of Cleveland itself, while the population served outside of Cleveland was 40,000 in one case and only 20,000 in the other, and that these populations bear the same proportion to each other as do the earnings of the respective roads that serve them.

In estimating the traffic from a proposed interurban road, you will find it unsafe to consider the population of your larger terminus. This larger terminus is extremely necessary for the success of such a road, for you must have some place to which the people along the line desire to go, but you will find that the people of the larger cities have little business and no inclination to leave their large city and ride out to the smaller points along the line, so you must begin by ignoring the population in the large city. You will also find that the much-talked-of farmer traffic is so small as to be almost a negligible quantity. The riding population which must be the source of your earnings, you will find to be the population of the villages and towns that you reach, who seek the large terminal for business or pleasure.

For the proper support of an interurban railroad this urban population, outside of the large terminus, should not be less than 750 per mile, and you will find that such a population will yield about five dollars per capita. Such a population will support an electric railway as ordinarily built, paying ordinary fixed charges on a bonded debt, large enough to cover the cost of its construction, but without profit to the promoters or stockholders. In order to be profitable, such a line should have an interurban population, outside of the larger terminus, of at least ten hundred per mile of track. Should this population, however, be less than 750 per mile of track, the proposition is likely to prove a financial failure unless built with extraordinary economy.

It is hard to discuss the cost of construction of interurban roads, because so few of them are built with real money. There is so much waste in the methods of the ordinary promoter, and his ways of raising capital are not only expensive, but his lack of credit makes the carrying charges during the period of construction extremely high. If built and paid for with real money these roads should vary in cost from $16,000 to $25,000 per mile, according to cost of right-of-way, weight of rail, and power and equipment used. In no case should they exceed this higher sum unless there exists in the particular place some physical difficulties, such as a large amount of tunnelling, rock cuts, or heavy bridging.

On the other hand, I have known one or two very profitable propositions doing good service in small communities that have been built for less than $15,000 per mile, these sums including in all cases the cost of power-house and equipment.

A PROPOSITION TO GENERATE GAS ON A LARGE SCALE AT COAL MINES AND TRANSMIT IT UNDER PRESSURE FOR LIGHT, HEAT AND POWER.

London fogs and possible economies in the utilization of coal have led Mr. Arthur J. Martin,* M. Inst. C. E., to present a series of three papers† on the long distance transmission of gas, before recent meetings of British scientists. In the earliest of these papers, and to a less extent in the second one, the relation between the fogs of London and the huge volumes of smoke produced from the 15,000,000 tons of soft coal consumed annually in the London Metropolitan Police District, with its 6,500,000 population, was discussed in some detail. This phase of the subject cannot be considered in the space at our command, which will be devoted instead to some of the points made regarding the generation of gas at the "pit's mouth" (the coal mines), and its transmission under pressure for the supply of light, heat and power to distant cities, and particularly to London. As being the latest of the three papers, we shall draw chiefly upon the one presented before the British Association for the Advancement of Science in August of this year. Before taking up that paper, reference may be made to precedents cited by Mr. Martin (in one of his earlier papers) in support of the transmission of gas under pressure for long distances. Mr. Martin remarks that in the United States natural gas has been transmitted as far as 200 miles and under pressures as high as 300 lbs. Manufactured gas has been transmitted under pressure to extreme distances of 52 miles by the Western United Gas & Electric Co., which supplies 24 cities and towns near Chicago with a combined population of 140,000. In England the South Staffordshire (Mond) Gas Co. supplies gas for power and heating to an area of 163 sq. miles between Birmingham and Wolverhampton.

In opening his British Association paper, Mr. Martin first outlines the recent rapid development in both gas and electric light undertakings in England. The gas supply of metropolitan London was for many years in the hands of a large number of small companies, which have since been consolidated into three large ones, but the electrical supply is now furnished by 16 municipal authorities and 13 private companies. A number of schemes for the generation of electricity on a large scale, to be supplied in bulk to the several local authorities and private companies, have been brought forward in the last few years but have not yet received favorable action by Parliament.

Aside from the economic arguments for the gas generation and transmission scheme proposed by the author, he cites the relation of coal consumption to London fogs (already mentioned), the pollution of the atmosphere in other ways by the products of combustion of coal, and the loss of such valuable by-products as ammonia and coal tar in the direct utilization of coal as compared with their recovery in the production of gas. The by-products obtained by the London Gas Light & Coke Co. are given as £1 13s. 7d. ($8.16) per long ton of coal carbonized. In considering the economic phases of his proposal, Mr. Martin says that the price of gas as now generated and distributed in Great Britain ranges from 11d. (22 cts.), as supplied for gas engines at Widnes, to upwards of 7½s. ($1.82) per 1,000 cu. ft. From the approximate total receipts for gas in the United Kingdom for the year 1904 (in round numbers $100,000,000), the average price per 1,000 cu. ft. was 2s. 8d. (65 cts.), which is some three times the price charged at

*7 Victoria St., Westminster, London, England.

†(1) "Smoke Prevention and Coal Conservation," contributed to the Conference on Smoke Abatement held in Westminster from Dec. 12 to 15, 1905, under the auspices of the Royal Sanitary Institute and the Coal Smoke Abatement Society; subsequently reprinted under the title of "How to Prevent Smoky Fogs." (London. Sanitary Publishing Co. 1 shilling.)

(2) "Coal Conservation, Power Transmission and Smoke Prevention," read before the Society of Arts on March 28, 1906, and printed in the Journal of the Society of Arts, March 30, 1906.

(3) "A General Supply of Gas for Light, Heat and Power Production," read before Engineering Section, G, of the British Association for the Advancement of Science, in August, 1906.

Widnes. The low price of gas at the place named, according to Mr. Isaac Carr, M. Inst. C. E., was due to (1) careful management, (2) efficient apparatus throughout, and (3) judicious coal buying. Mr. Martin states that there is no reason why Widnes should have a monopoly in management or in efficiency of apparatus. The price which it pays for coal is only some 25% less than the average for a large number of gas undertakings in Great Britain.

The average price paid for coal by 113 of the largest gas works in the country, producing altogether two-thirds of the total gas output, is 11s. 2d. ($2.71), according to figures published by "The Gas World." The average value of coal at the mines is probably between 6 and 7s. ($1.46 and $1.70). But Mr. Martin states that the difference between the two figures "does not adequately represent the real cost of carriage, as it takes no account of coal lost in course of conveyance and handling, or of the deterioration which it undergoes in transit."

The chief advantages which gas has over electricity for transmission purposes, according to Mr. Martin, are as follows:

(1) The greater economy of gas transmission, the loss of power over a long distance being reducible to about one-quarter of that by electricity; (2) the absence of conversions from low to high voltage and back to low; and (3) the possibility of storing gas cheaply and without loss, and using it in whatever quantity and whenever required; whereas the generation of electric current must keep pace with the consumption at any moment. This last consideration is largely responsible for the high proportion which the capital expenditure of electrical undertakings bears to their earnings.

The author next proceeds to discuss in some detail the objections most likely to be raised against the conveyance of gas under pressure for long distances, none of which, he thinks, are of sufficient importance to make his proposition other than feasible. He next outlines a plan for generating gas sufficient to supply metropolitan London from a plant located in the South Yorkshire coal fields. This would involve a transmission line about 173 miles in length for the conveyance of some 40,000,000,000 cu. ft. per year. For this purpose he thinks a single 25-in. pipe, under an initial pressure of 500 lbs., would suffice, and he believes that the necessary compression could be secured by about 46,000 HP., "the greater part, if not the whole, of which might be obtained from steam raised by the waste heat from the retort ovens." Including interest, depreciation, taxes and operating expenses, Mr. Martin estimates that the cost of gas at the coal mines, delivered to the compressors, will be 5⅝d. (11 cts.) per 1,000 cu. ft., and that the cost of compression and transmission, including allowance for leakage, would bring the cost of gas delivered to the present holders in London to 7½d. (15 cts.). With this figure there may be compared a cost in the holders of 12.85d. (26 cts.) as the average for the three metropolitan companies in 1904.

If, instead of displacing gas, only, the plant was developed to displace all the coal now burned in London, a total of 180,000,000,000 cu. ft. per year would probably be required, demanding four 30-in. conduits and making it possible to bring the price for gas down to 1s. (25 cts.) in place of the present average of 2½s. (61 cts.) per 1,000 cu. ft. As this proposal involves delivering gas in London with a pressure of 250 lbs. per sq. in., Mr. Martin suggests that by utilizing this pressure a large amount of electricity could be developed, and that this could be supplemented, if desired, by generating more electricity by means of "gas engines at less than one-third the average cost now incurred for fuel by the 25 metropolitan electrical undertakings." He says, further:

The gas used to generate electricity by expansion would leave the motors at a temperature far below zero, the cold thus produced being more than ample for manufacturing all the ice now used in London, and for cooling extensive refrigerating stations in addition. No profits from the sale of electricity or ice have been taken into account in arriving at the selling price of the gas.

Before concluding his paper, Mr. Martin outlines the possible development of gas supplies at low cost for smaller cities, particularly those like York, Leeds and Manchester, that are near coal fields.

A NEW TACHOMETER.

The bi-fluid tachometer illustrated in Figs. 1 and 2 herewith is designed to indicate speed of rotation by the centrifugal effect upon a liquid contained in a rotating vessel, the differences in level produced thereby being magnified by employing two liquids of widely differing densities. How it accomplishes this may be seen by examining the drawing A in Fig. 1, which represents (somewhat diagrammatically) the rotating element of the bi-fluid tachometer, after the carrying frame and bearings have been removed. The heavier liquid, mercury, is contained in two small closed hemispherical cups at the base, which are disposed symmetrically to the vertical axis of rotation. At the outer edge of the cover of each cup a small opening communicates with a riser filled with the lighter liquid, which is colored to be better visible; the two risers join and lead to a vertical central indicating tube of small diameter. When the instrument is rotated about its vertical axis, the mercury tends to assume the paraboloidal surface of a free rotating liquid, and thereby sets up a pressure at the base of the riser tubes, proportionate to the speed of rotation. This pressure, represented by a given difference of level at a free mercury surface, requires a much higher column of the lighter indicating liquid to balance it, in proportion to the relative densities of the two liquids. Consequently, the liquid in the indicating tube rises a relatively large amount, and a scale alongside, calibrated in speeds of rotation, gives a direct reading of speed.

The indicating tube is open at its upper end, and is surrounded and enclosed by a second glass tube, called the return tube. This latter is closed to the air at top and bottom, and from its lower end two small return drains lead to the mercury cups, by way of an opening at the inner edge of the cover of each cup. This arrangement is a protection against running the device at a speed exceeding its capacity; when the colored liquid is forced above the top of the indicating tube, it overflows into the return tube and drains back to the cups.

The combination of cups and tubes, just described, is mounted and arranged for convenient use as a tachometer in various ways, depending upon the nature of the intended service. One style is represented in sketch B of Fig. 1. The lower part of the completed device, as here shown, is a metal case, while the upper part is a wide glass tube surmounted by a metal cap. A step-bearing is formed in the lower part of the base-section, and a corresponding bearing in the cap; these bearings engage the spindle ends of the rotating element. The latter comprises the assemblage shown at A, subsequently mounted in a metal shell or carrying-frame, which encloses the cups and connecting tubes; a spindle projects from the bottom of this shell, and another from the top of a metal cap fitted to the upper end of the return tube, which spindles engage the bearings mentioned. The lower spindle also carries a bevel gear, meshing with a bevel on a horizontal driving shaft journaled in a bearing in the lower part of the case. A band-wheel on the driving shaft affords means for coupling the instrument to any shaft whose speed it is desired to measure.

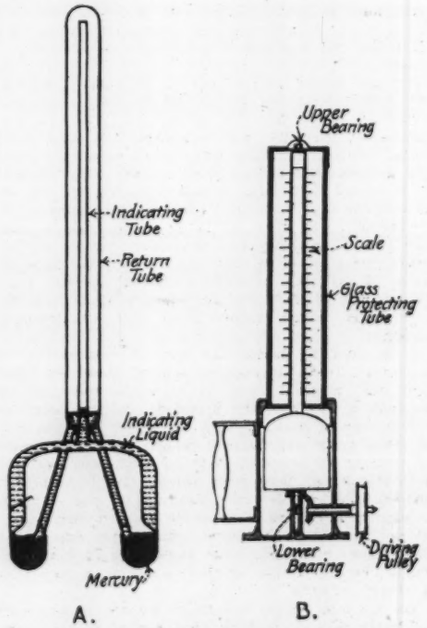

Fig. 1. Sketches Showing Construction of the Bi-Fluid Tachometer.

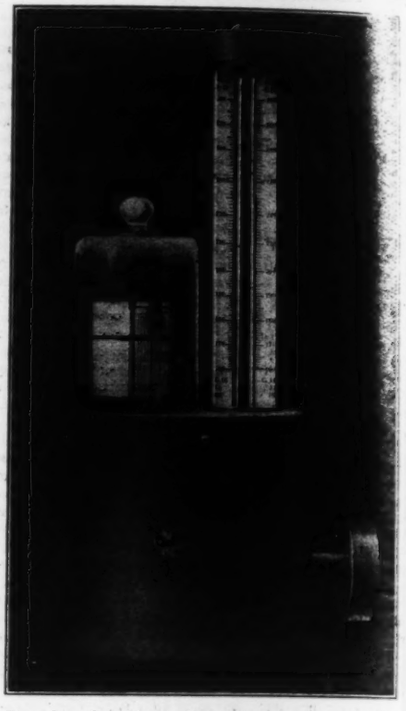

Fig. 2. Combined Recording and Indicating Tachometer.

The range of the scale of this type of tachometer is about 1:4, i. e., the maximum speed which it will indicate is about four times the minimum. Besides various styles of indicating instrument, a combination recording and indicating tachometer is also made. This latter, shown in the photographic view, Fig. 2, is in reality two instruments, one indicating and the other recording, set in a common case.

The bi-fluid tachometer here described is the invention of Mr. G. Saaler, and is manufactured by the Niagara Tachometer & Instrument Co., of Niagara Falls, N. Y. The advantages claimed for it are: Permanency, accuracy, sensitiveness, low cost of maintenance, simplicity of construction, and insensitiveness to temperature variations.

THE OSRAM ELECTRIC LAMP was exhibited at the last annual convention of the German Association of Electrical Engineers. The lamp is made by the Welsbach Co., of Berlin, and is said to show a saving in power consumed, as compared with the ordinary carbon filament incandescent lamp, of 70% to 75% for lamps of 110 and 220 volts, respectively. The average life of these lamps is given as 1,000 hrs., as against 800 hrs. for the carbon filament lamp. The consumption of current per candle-power varies from 1 to 1.25 watts, depending on the size and voltage of the lamp, while for the carbon filament lamps the consumption runs from 3 to 5 watts per candle. The candle-power and consumption of the Osram lamp is nearly constant throughout its life, the candle-power increasing slightly for the first 200 hrs., with a slow decrease thereafter, while on the other hand the consumption decreases for the first 200 or 250 hrs. after which it very slowly increases.

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The most notable example of the adoption of the iron sulphate and lime process of clarifying water is in connection with the new water supply of Cincinnati, where these materials are to be used instead of alum for the removal of sediment from the water prior to its filtration. In another part of this issue we present a paper by Mr. Ellms, the Chemist of the Cincinnati Works, describing the application of the process there.

There has been, we believe, some suspicion of this process on the part of sanitarians on account of the extravagant claims which have been made for it in certain publications. It has been advocated as a cure-all, and sufficient in itself, without filtration to render all waters pure and wholesome. Mr. Ellms discusses the process, however, from an unprejudiced point of view. He brings out clearly the strong points of merit which the process undoubtedly possesses and shows that its great advantage over the alum commonly used in mechanical filters is in treating such waters as those found throughout the Ohio and Mississippi valleys, containing large amounts of sediment. We are sure that the paper will be appreciated as a valuable contribution to the literature of water purification.

The transcontinental railway system has not for many years been the scene of such activity as at the present time. The San Pedro, Los Angeles & Salt Lake Ry., which was opened in February, 1905, was the forerunner of a number of important projects, and a number of new lines are now actually under construction, while other projects are in various stages of promotion, so that there will be some notable additions to the transcontinental lines within the next few years. An article describing some of the most important of these new lines is published in another column. It is, of course, well known that there is no one transcontinental railway in this country, that is a railway under one ownership extending from the Atlantic to the Pacific; all transcontinental traffic must pass over at least two distinct lines (usually more). While no new routes to the coast have been established for some years previous to 1905, the older lines have by no means been idle, but have carried out very extensive improvements in the way of reducing grades and curvature, double-tracking, rebuilding bridges, etc., and a number of these works have been described from time to time in our columns. There is little doubt that the existing lines and new lines under construction will provide ample facilities for the accommodation of through traffic for many years, and railway extension in the future (as in the recent past) will consist mainly of branches and new lines to open up new districts, to improve existing routes, or to link up isolated lines to form new routes. In such work, the importance of the new lines, is not to be measured by their length but by their engineering features and their traffic or operating conditions.

WHAT ARE THE POSSIBILITIES IN OPERATING THE MOUNTAIN DIVISIONS OF WESTERN RAILWAYS WITH ELECTRIC POWER?

A correspondent in this issue describes opportunities for the use of electric current, generated by water-power, to operate the mountain divisions of railways in the Far West. From other sources we understand that investigations and estimates of the cost of electric operation on the Sierra Nevada section of the Southern Pacific are being prepared by engineers of the two largest electric companies. It is "in the air," so to speak, that in the East, the utilization of the power of Niagara to propel trains on steam railways, is one of the engineering feats to be expected in the near future. It seems worth while, therefore, to discuss some of the problems that face the engineers who are set to harness the great powers of Nature in this manner.

On its face the problem seems an easy one. Here is a mountain torrent dashing down thousands of feet. Here is a train toiling along up the mountain side, burning coal to obtain its power. To harness the torrent and set it to producing electric energy is nowadays an ordinary and well-understood task of the engineer. To transmit that energy along the track and apply it to the propulsion of the train is also a task for which ample precedents now exist. When, however, we attack the problem from the commercial side the difficulties begin. It is not a question whether the mountain torrent can be harnessed to the train; but whether, when the harnessing is done, the new steed will not be found more costly to buy and to keep than the faithful and well-tried nag which is now in service.

Railways are normally operated to earn money for their stockholders. If the use of electricity will so reduce expenses or increase earnings as to leave a larger net surplus at the year's close, then the way to the use of electricity is easy. But if no showing of this sort can be made, then the use of electricity on steam roads will be limited to lines where other considerations than economy make a change imperative.

It is a fact that the most notable cases of electric installations on steam railways now before the public belong to this latter class. The tunnel entrance of the Pennsylvania and New York Central systems into New York City compelled the installation of electric motive power. The same may be said of the electric equipment of the St. Clair tunnel. There are other tunnels, such as the Cascade tunnel on the Great Northern, where electric operation is probably inevitable, and where the operation of a tunnel in this way will very likely be extended to include a longer section than the tunnel itself. So, too, in suburban traffic, the special advantage of electric traction in freedom from smoke, more rapid acceleration, adaptability to frequent service and consequent attractions to travel, are likely to bring about an extensive use of electric locomotives.

But when we come to main line traffic, none of these considerations apply. The question is, then, whether a saving can be figured out for the substitution of electricity for steam on some of the mountain divisions of railways in the Far West where water power is available.

The first difficulty that confronts the engineer who is figuring on this problem is the great variation in the loads to be carried by the power station. It is assumed that what is desired is to move by electricity the trains on a mountain division of a main line railway, perhaps 30 to 50 miles in length. The power station must be designed to furnish current to the largest number of trains that are likely to be run on this division at one time, and while all these trains will not be starting at once or climbing a grade at once, yet allowance must be made for the chance that a considerable proportion of them will be doing hard work simultaneously.

The shorter the division which the power station supplies, the more unfavorable will the load factor become; and while the installation of electric locomotives will often be taken advantage of to haul longer trains, it must be remembered that increase in the power of the locomotives will also affect the load factor unfavorably.

Of course it will hardly be questioned by any one at all familiar with railway operation that electric locomotives and not motors on the individual cars must be adopted in installing electricity on steam railways. Even if motors were applied to the cars, on the multiple unit system, the load factor would not be helped, except to the extent that the power required for the electric locomotives themselves would be eliminated. However advantageous the individual motor car may be for handling an exclusively passenger traffic on city or suburban lines, conditions on steam railways compel the movement of trains hauled by locomotives; and safety of operation, if nothing else, forbids consideration of any proposal to reduce the length of trains and increase their number.

Again, in estimating the number of trains which may be bunched upon a division and thus may make demands on the power station supplying it, it is not regular traffic, but emergency traffic that must be provided for. A blockade may occur, due to wreck or washout, and a lot of through freight, perishable, perhaps, may be bunched up behind the wreck, and be rushed forward, when the blockade is raised, in trains following as close after each other as safety will permit. Or, again, some special excursion may bring several sections of long passenger trains close behind one another, over the road, in addition to the regular traffic in both directions. Allowance must be made, too, for the steady and rapid growth in traffic which all main line railways are experiencing.

After a reasonable assumption has been made, from a study of past traffic records, for the maximum number of trains that may be run on the proposed electric division at one time, the next assumption to be made is the average power consumption per train. Here, too, it is necessary to be liberal. An electric locomotive climbing a steep grade will often work considerably above its rated capacity; and trains with double-headers and sections following close after each other must be provided for. Just what power output should be assumed will, of course, have to be studied for each case separately. For the sake of obtaining an approximate idea of what is involved in the introduction of electric motive power, let us assume that the power station must have sufficient capacity to supply 500 HP. per train when the maximum number of trains is on the division. This is the power measured at the driving wheels of the electric locomotive; and there is under any system a large loss between the energy delivered at the power house switchboard and that exerted at the car wheels. If we assume the combined efficiency of the locomotive motors, the transmission line, transformers, etc., to be 65%, then the power station must have a capacity of about 770 HP. for each locomotive in service.

Now for a rough and ready method of estimating the cost of this water-power, suppose we assume that $20 per HP. per annum is a fair average cost of electric current generated by water-power and delivered at the switchboard. There are, of course, exceptionally favorable locations where water-power can be developed at less cost than this; but on the other hand there are plenty of cases where the cost will be greater, when fair allowance is made for depreciation and maintenance. It must be remembered, too, that a railway cannot be taken to the favorable locations for power plants, but such water-powers as

may exist adjacent to the line must be utilized, whether they be easy of development or the reverse. Again, the cheapest operation of the power plant is obtained when a single huge station supplies the entire line. With the large amount of power required to operate a main line railway, however, this will seldom be possible. What will have to be done is to collect current from a number of small plants, each utilizing the waterfall available at a given point, and the operating expenses of several small stations will be necessarily much heavier than the same output from a single large station.

It is true that the figure of $20 per HP. per annum above assumed refers to continuous power, whereas the railway's demand for current will fluctuate greatly, and a current output equal to the power station's capacity will seldom be reached. In the case of a water-power station, however, the expense is almost as great as if the station were run at full load all day long and every day of the week. The interest and depreciation charge on the original investment, which is the chief item of cost in a water-power plant, remains substantially the same, whether the whole plant is run or only a single unit. The expense for attendance is little less, since the staff must be sufficient to run the station under full load at any time. Only the bill for oil, depreciation and repairs on the machinery, is reduced by a small load factor, and this bill is not the large item of expense in a water-power plant.

We shall not be far wrong, then, if we assume that the railway adopting electric power under the conditions assumed will have to expend for electric current about $20 \times 770 = \$15{,}400$ per annum for each locomotive in service. To offset this expenditure, it will save the cost of fuel and water for locomotives, and in addition it will save probably, two-thirds, more or less, of its present expense for locomotive repairs. The first cost of the electric locomotives, however, will be probably double what the steam locomotives cost, and there will be, therefore, a larger interest and depreciation charge against them. There will also be an investment amounting to several thousand dollars per mile of road on the transmission system from the power house to the track, on rail bonding, etc., and an annual charge for interest and depreciation must be made on this account.

Summing up the whole situation, then, it is difficult to see how any considerable profit can be figured out in the proposal to substitute electric locomotives in place of steam, even on these lines in the West where water-power is available, so that the chances for profit on the change are better than exist elsewhere. There may be exceptional locations, of course, where large water powers susceptible of development at moderate cost exist close to the railway, or where locomotive fuel is particularly costly. Either of these conditions, or both in combination, may perhaps enable a project for electrification to show a moderate profit.

It is to be said, too, that other considerations, such as the existence of long snowsheds or numerous tunnels, may make a change to electric power justifiable. On the other hand, we believe all experienced railway officers will agree that for the movement of traffic under steam railway conditions, a motive power which is independent on every train is far preferable to one which ties every train to a central power station and which puts it within the possibilities for a minor accident in the power station or on the transmission line to paralyze every train on the road. This is a feature of electric operation concerning which its advocates have little to say. The public has become in a certain degree accustomed to it on street railways, where distances are short and one can walk, and on interurban lines, where a parallel steam railway can usually be found to take passengers in such times of emergency. But if the entire movement of main line passenger and freight trains may be arrested by the breakdown of a generator or a fire in a power house, or a wreck on a transmission line, perhaps 30 to 40 miles in length, a much more serious situation is presented. That such accidents will occur more or less often is certain; as is proved by the records of power stations and long transmission lines generally. If necesssary, of course, such blockades can be endured, but it should be clearly understood in considering any proposition for electrifying a steam railway that this is one contingency inseparable from electric operation.

In what has preceded, we have considered the problem solely with reference to the use of water power for generating the electric current, and therefore under the conditions most favorable to the use of electricity. It will be apparent that if water power is not to be had and fuel must be burned at the power station to produce power for driving the generators, then the operating expenses will inevitably be increased not only on account of the coal or other fuel burned but because of the increased labor necessary for operating the plant.

We are well aware that the advocate of electric motive power, when he finds it impossible to figure out a saving in the total of operating expenses and fixed charges by the change from steam to electricity, falls back on the argument that electric motive power will bring increased traffic. This argument has enough semblance of truth to deceive many; but it is actually based on a fallacy. But, it is said, look at the astonishing passenger traffic which the interurban railways secure. In many cases, undeniably, they have taken a large share of the traffic which formerly went by the steam roads, and they have in addition built up a business which did not exist before. To many this seems to prove that electric railways can command traffic that steam railways cannot. Let us see, however, whether this is really a valid argument for the electrification of steam railways. A little inquiry shows that people do not ride on an interurban car merely because it is propelled by electricity. It is because the service is frequent, and the car takes passengers from every street corner instead of starting from a railway station and depositing its passengers at another station, which may be a mile perhaps from their destination in the town. This is the great traffic-drawing card of the interurban railway. Such matters as cleanliness and smooth running may influence a few passengers, but they are comparatively unimportant.

Now the bearing of all this on the electrification of steam railways is obvious. A steam railway altered to electricity cannot run frequent cars or trains like its interurban competitor, on account of the freight traffic which occupies the tracks. It cannot, as a practical matter, run its cars or trains over the street railway tracks. Although proposals to do this have been made, there are difficulties in the way that have never been overcome. The change to electricity, therefore, will not aid it in competing for suburban or interurban passenger business.

LETTERS TO THE EDITOR.

A Comment on "The Passing of Cable Railways in the United States."

Sir: In your issue of Sept. 20 I note the article on "The Passing of Cable Railways in the United States." In this article I see no reference to the elevated railroad on Greenwich St., New York City, whose first motive power, to run cars, was a "cable." It may be that the article referred to only applies to "surface roads;" if not, I think the efforts of the elevated road to run cars by means of a cable should not be overlooked.

W. R. Cock.

120 Liberty St., New York, N. Y., Sept. 20, 1906.

The Use of Coal Tar to Lay Dust on Macadam Roadways.

Sir: In the Engineering News of Aug. 23, 1906 (p. 211) figures are given showing the cost of material and quantities used for treating macadam roads with coal tar in England. This, as well as some other reports of work which has been done in Europe, gives quantities much under what has been used at any point in the United States. We have furnished a considerable quantity of material for this work, and in no case has less than 0.3-gal. per sq. yd. been used, while your reports give only 0.165-gal. per sq. yd.

We are sending you herewith a report issued by the Public Roads Office at Washington, giving data of work, which was carefully done, using about 16,000 [illegible] of the material, at Jackson, Tenn., last year.

Yours respectfully,

Barrett Manufacturing Company,

F. S. Hutch[illegible]

17 Battery Place, New York, Sept. 19, 1906.

[The gist of the report on the tests of co[illegible] tar at Jackson, Tenn., was given in our issue o[illegible]ly 5, 1906.—Ed.]

The Adaptation of the Pitot Tube for the Measu[illegible]ent of Hose Nozzle Pressures and Discharges.

Sir: In your issue of Sept. 13 appears an arti[illegible] by Mr. F. B. Sanborn descriptive of a Pitot devi[illegible] for measuring the pressure and discharge from hose n[illegible]zles.

Mr. Sanborn states that the device was develo[illegible] recently by him. Without wishing in any way to [illegible]ract from the credit which may be due Mr. Sanborn, [illegible] to give credit where it is due, permit me to call att[illegible]ion to the fact that the device in question was used [illegible] the Committee of Twenty of the National Board of Fire Underwriters in all of its fire engine, pumping [illegible]gine and hydrant tests, and that it was used for several [illegible]ears previously in the Boston fire department by its designer, Capt. Greely S. Curtis, now consulting engineer, Whitehall Building, New York. Furthermore, the water department in this city and several fire departments were either furnished with the device by the National Board or allowed to copy it. Being a simple utilization of a simple hydraulic principle, its designer claimed no particular credit for it and made no effort to patent it.

Reference to the reports of the Committee of Twenty, copies of which you have, will show the extent to which the device was used. See remarks under "Hydrant Tests" in New York report, for instance.

Yours truly,

S. H. Lockett.

46 Cedar St., New York City, Sept. 14, 1906.

[Professor Sanborn submits the following reply to Mr. Lockett's letter.—Ed.]

Sir: I am pleased to learn of the extent that Mr. Curtis' device for measuring nozzle pressures has been used. I had known that Mr. Curtis had used a form of this device for his own testing, but I was not aware that it had been in general use by the Committee of Twenty.

Mr. Curtis' device, as I have just learned, consists of a Pitot tube with a "cut-water," connected by ¼-in. pipe fittings to a pressure gage. I fail to see that this is materially different from the simple form of Pitot tube used by Mr. Freeman in his well-known experiments (Trans. Am. Soc. of C. E., 1889), ten years before Mr. Curtis first used his form. And Mr. Freeman's tests were, of course, merely improvements over early tests, for since 1730, when Pitot developed the original form, there have been frequent modifications and tests with one form and another of this device.

The developments that I believe to be original with me are: The addition of shield and special form of cut-water (or divider), both of which I have found to be important elements in preventing spattering, not breaking the stream badly, and allowing quick and accurate readings; the curved body portion that fits onto the nozzle; the three-way cock with connection for taking static pressures and for blowing out; the gage graduated to read both pounds and gallons direct and constructed with an auxiliary spring so as to withstand the unusual impulse to which a gage for this purpose is subjected. Therefore, although credit is due Mr. Curtis for the development of the form that he has used, also to the Mechanical Superintendent of the American Fire Engine Co., at Seneca Falls, N. Y., who, I have understood, used several years ago some form of Pitot tube for testing the pressure of fire streams, yet the form that I have developed is original with me and differs, I believe, from earlier forms in the ways indicated above.

F. B. Sanborn.

Tufts College, Mass., Sept. 20, 1906.

Opportunities for Water Power Electric Plants to Supply Railways on the Pacific Coast.

Sir: The writer has resided all his life in and around the Western mountains, and has been connected with the installation of most of the hydro-electric power stations built in California in various capacities. Being familiar with the country, and with this type of hydraulic machinery, he ventures a few remarks on the ease with which the Western mountain railroads could be furnished with cheap electric power.

Beginning at San Francisco, and following roughly the routes of the Southern Pacific and the proposed Western Pacific we find small encouragement for a power plant until Sacramento is reached. Here we find the Sacramento River, and a few miles above, the American; but both are in flat country and various attempts to dam the American, even higher up, have only proved disastrous, because of length of dam and great floods. The

great power plant higher up on this river is well known, and there is plenty of room for others, but the water rights are all bought up.

Next, just before entering the snow sheds of the Southern Pacific, we come upon one of the grandest natural opportunities that Nature gives to man. On the right is a huge canyon, one end of which is closed by the ridge on which the train crosses it, and the other is almost closed by a huge natural dam, which, at a distance, has the appearance of a geological "dike." On each side of the reservoir is a large drainage slope, covered with underbrush and a few trees. Numerous streams can be seen and even heard, flowing into the canyon, and the writer at one time saw the sides covered with snow, and the canyon full of snow, as though avalanche after avalanche had rolled into it, which speaks well for the supply of water. A comparatively small dam, only, is needed to fill the reservoir, the depth of which is regulated only by the height of the dam, as it is easily a thousand feet to the top of the surrounding ridges. The canyon from the dam site downward has a heavy grade, and a pipe leading down to a suitable power-house could develop a very desirable amount of power.

Then there is the Truckee River, on which there are dozens of places to develop power.

Near the route of the Western Pacific, in Lassen County, California, north of Honey Lake, is a splendid opportunity to tap Eagle Lake, getting a fall of some hundreds of feet and developing unlimited power, the tail water of which can be used to irrigate Honey Lake Valley, now a desert, but which raises excellent crops and makes good dairy land when irrigated. This valley was very fertile fifty years ago, but emigrants cut off the lumber and burned the grass and it became a waste. It includes over 100,000 acres of the finest kind of unirrigated land.

Lake Tahoe could be tapped without enormous cost, and without harming the lake, as its present outlet could be closed. A tunnel would be necessary, from which a pipe line one hundred miles long paralleling the railroad would have over 5,000-ft. fall. Stations placed twenty miles apart, using the water in series, could depend on 800-ft. head; this with a 41-in. pipe, would be sufficient to give about 4,000 HP., or sufficient to run the road, light it, run the shops, and sell electricity to adjoining towns. The reader will note that the 4,000 HP. applies to one section of 20 miles only, or 20,000 HP. in all.

Through Utah and Colorado, on the Rock Island, for instance, there are many opportunities to dam narrow canyons, such as some of the tributaries of the Royal Gorge, the White, Bear or Snake canyons.

At Tennessee Pass, on the western side of the tunnel, are several insignificant appearing streams, but on the left-hand side there is almost a straight drop for a pipe of apparently several thousand feet. Probably enough power could be generated here to pull trains up the grade, particularly if larger power-houses on some of the larger rivers were working at the lower end.

It would be well if a type of electric locomotive were developed that could utilize its motors on long down grades to generate current for the line, but experiments in this direction have not proved encouraging. There is no doubt but that the traffic can be handled most economically by electric locomotives. They can start and haul a larger train than steam locomotives because the starting torque is greater, the same rails can take a much heavier electric engine, and the torque is absolutely constant, giving a smooth, steady pull.

E. N. Percy.

Berlin, Germany, Sept. 8, 1906.

Building Departments and Reinforced Concrete Construction — A Test of a Warehouse Floor.

Sir: In an editorial some time since, relative to the attitude of the various building departments towards the new type of construction, reinforced concrete, you called attention to the ultra-conservatism which seems to govern these departments in their consideration of anything novel in this line. While they will readily accept timber frame construction, figured on the basis of a factor of safety barely above two, in reinforced concrete they will commonly request that the concrete construction should be tested over large areas to three times the working load without injury at a period when the construction has not attained 60% of its ultimate strength.

Again, the pioneer or promotor of anything new or novel along this line often finds much difficulty in obtaining a permit, even though his design is only slightly different from that which has been previously put up along that line.

As a pertinent example, I hand you herewith a photograph (Fig. 1) showing the reinforcement of a new five-story building in this city (Minneapolis), taken before the concrete was poured.

This novel type of reinforced concrete construction is called the "mushroom" construction, and was invented by the writer, and was first described in your issue of Oct. 12, 1905. It differs from types hitherto put in, in the fact that the reinforced floor consists of only a plain slab and supporting columns, thereby obviating the large amount of work required for forms where ribs are used and the waste of lumber in cutting for the same. The column capitals (see Fig. 2) are molded in cast-iron forms. In this building the cast-iron capital forms were removed as early as 12 or 15 hours after the concrete was poured, thereby enabling six of these forms to answer for 48 capitals.

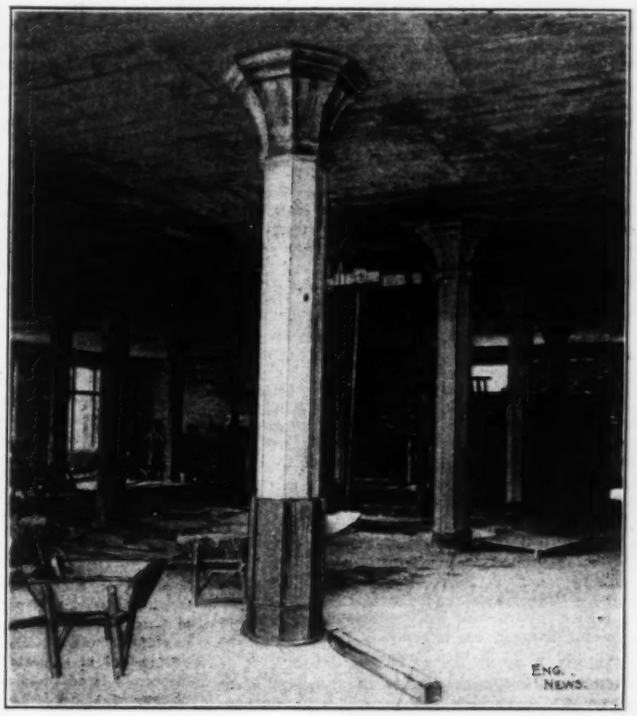


FIG. 2. UNDER-SIDE OF FLOOR IN BOVEY BUILDING, SHOWING CAPITALS OF CONCRETE COLUMNS MADE IN CAST-IRON MOLDS.

To the engineer realizing the effect of reinforcement in a number of directions on such a composite material as concrete such a construction would naturally appear more favorable than any of the ordinary types, and the numerous prophecies of failure under test load that were made by many having a limited familiarity with this class of construction would undoubtedly be of interest to your readers. The fact that there is a large concentration of metal around and near the columns, where the ordinary building is generally loaded the heaviest, is one of the advantages claimed for this type of construction, in addition to the simplicity of the centering and economy of materials. This construction is especially adapted for warehouse purposes, particularly those carrying the heaviest loads, with spans from 16 to 18 ft., and the economy of the construction over other types increases rapidly with the increase of the working load.

In applying for a permit for this building the Building Department refused to grant one, except for an experimental building, it being agreed and understood between the owner, the engineer and the contractor that the construction should stand a test load of 700 lbs. per sq. ft. of floor, with a maximum deflection of ¾ of an inch in the center of the slab. While nothing of this type had, as far as the designer, the owner or the contractor was aware of, been erected prior to this building and no tests had been made, each were sufficiently satisfied as to its stability to proceed with the erection of a five-story building complete before making any tests.

The test load consisted of a pile of wet sand, 5 ft. in front and 5 ft. 6 ins. in back, covering one panel, crushed rock to the same depth covering the other panel, and on top of this pile, which was boarded in, cement in sacks, four deep, covering the same area. The sand was very wet and was figured at 100 lbs. per cu. ft. The sample boxes, holding 1 cu. ft., weighed 105 to 107½ lbs., giving an actual load of 750 lbs., which was rated at 700 lbs. The elastic deflection was a scant quarter of an inch; thickness of the rough concrete slab was from 7½ to 7¾ ins., with 1½ ins. of strip filling on top; the slab was about 10 weeks old, and the strip filling had been in about three weeks or thereabouts.

Since the completion of this building a five-story wholesale grocery building, 130 x 140, for the Hoffman Bros., of Milwaukee, has been contracted for and is now under construction by the Northwestern Tile Co., of that city. Ferry & Clas are the architects and John Geist consulting engineer. Another building is now under contract in the city of St. Paul, to be 235 x 165, seven stories in

FIG. 1. THE "MUSHROOM" SYSTEM OF STEEL REINFORCEMENT FOR CONCRETE FLOOR CONSTRUCTION; C. A. BOVEY BUILDING, MINNEAPOLIS.

height, for which Louis Lockwood is the architect and Butler Bros. the contractors. In St. Paul the requirement is that we shall test four panels adjacent to each other with 500 lbs. per ft. for a floor load, which will probably never exceed 150 lbs. wholesale dry goods, while the building is figured for a working load of 250 lbs. per ft. (panel size, 13 ft. 4 ins. × 18 ft.), or a total test load of 480,000 lbs. to handle!

It may be of further interest to your readers to know that the bid of the Butler Bros. on this St. Paul building in reinforced concrete was $10,000 lower than their bid on the same building in timber mill construction, and it is rumored that this proposition on reinforced concrete was between $30,000 and $40,000 under bids on other systems.

Yours truly,

C. A. P. Turner.

Phoenix Bldg., Minneapolis, Sept. 15, 1906.

Notes and Queries.

Referring to the letter on "Cross-Section Books or Separate Sheets for Taking Topography," in Engineering News of Sept. 6, 1906, the writer of the letter informs us that the contours mentioned in the seventh line of the third paragraph measured 5 ft. instead of 25 ft., as printed.

The construction of the train-shed of the Delaware, Lackawanna & Western R. R., at Hoboken, N. J., was erroneously stated to have been done by Mr. J. E. Snell, Superintendent of Buildings and Docks, in the descriptive article by Mr. C. C. Hurlbut in our issue of Sept. 20. Mr. Snell constructed all of the foundations of the building beyond the bulkhead line. The construction of the train-shed, however, was in charge of Mr. E. I. Cantine, M. Am. Soc. C. E., Division Engineer of the railroad.

In Table VIII., "Offsets to the Six-Chord Spiral," at the top of p. 270, in Engineering News of Sept. 13, the table will be clearer if two vertical lines are drawn between the columns as shown on the reduced copy of the table below.

TABLE VIII.—INTERMEDIATE OFFSETS TO THE SIX-CHORD SPIRAL FROM MAIN TANGENT, MAIN CURVE AND TERMINAL CURVE.—To be measured inward for the main tangent half of spiral and outward for the main curve half.

Tenths of chord length.	Coefficients which, multiplied by P give offsets in feet.	Tenths of chord length.	Differences for each hundredth of chord length.	Tenths of chord length.	Coefficients which, multiplied by P give offsets in feet.	Tenths of chord length.	Differences for each hundredth of chord length.	Tenths of chord length.	Coefficients which, multiplied by P give offsets in feet.	Tenths of chord length.	Differences for each hundredth of chord length.
P S	.000	S_9	.0000	S_1	.086	S_8	.0008	S_2	.054	S_7	.0004
1	.000	9	.0001	1	.042	9	.0008	1	.050	9	.0004
2	.001	8	.0002	2	.048	8	.0004	2	.046	8	.0005
3	.003	7	.0003	3	.052	7	.0004	3	.041	7	.0005
4	.006	6	.0003	4	.056	6	.0003	4	.036	6	.0005
5	.009	5	.0004	5	.058	5	.0001	5	.031	5	.0005
6	.013	4	.0005	6	.059	4	.0000	6	.026	4	.0006
7	.018	3	.0005	7	.059	3	.0000	7	.020	3	.0006
8	.023	2	.0006	8	.059	2	.0002	8	.014	2	.0007
9	.029	1	.0007	9	.057	1	.0003	9	.007	1	.0007
S_9	.036	S_8		S_8	.054	S_7		S_7	.000	S_6	

Engineers who have transferred this table to their notebooks or who desire to correct their files of the paper can readily add the vertical lines suggested with a pen.

SULPHATE OF IRON AND CAUSTIC LIME AS COAGULANTS IN WATER PURIFICATION.*

By Joseph W. Ellms.†

The development during the past five years of the method of using sulphate of iron and caustic lime for coagulating turbid waters, which are utilized as municipal supplies, is both interesting and instructive. It is interesting because their adoption has been hastened by a popular prejudice against the use of alum for such purposes, quite apart from economic reasons which would have eventually caused their employment anyway; and instructive because the method virtually embodies the principles involved in several other well-known processes which have been used heretofore with varying degrees of success for effecting the same results. It is hardly worth while examining into the reasons which are the alleged basis for the antipathy of the public toward alum, except to say that sanitarians must pay some attention to the demands of the consumers in this matter even though their aversion to this chemical is quite unfounded. As long as they pay the bills they are not a factor which can be entirely ignored.

In those methods of purification which require the use of chemicals, the cost of the latter is no inconsiderable proportion of the whole, and for this reason sanitary engineers have long been desirous of reducing the fixed charges of operation to a minimum. Since the salts of aluminum and iron appear to be the only ones particularly suited for coagulation purposes, the use of the cheaper sulphate of iron in place of the more expensive sulphate of aluminum has long been a great desideratum. But the difficulties in applying the iron salt did not appear to be easily overcome, and as the reasons for these are largely physical and chemical it may be of interest to consider briefly what takes place in a water treated with the above-named compounds.

We are accustomed to speak of natural waters as soft or hard, according to the amount of soap which is used up before a lather can be obtained. These terms are merely relative, however, and those salts in the water which use up the soap are the same in both soft and hard waters, merely differing in amount. There are, however, two general classes of salts in a natural water which produce the effect of hardness, but only one of these reacts with compounds like sulphate of aluminum or sulphate of iron when these chemicals are applied as coagulants. This class comprises the carbonates of calcium and magnesium, and are commonly spoken of as those compounds which produce the temporary hardness of a water. In the case where one applies sulphate of aluminum to a water containing bicarbonates of lime and magnesia in solution, the latter are partially or wholly destroyed, depending upon the amount of alum added. As a result there are formed sulphates of lime and magnesia which remain in solution and which produce the so-called permanent hardness of the water, and an insoluble compound called aluminum hydroxide which is precipitated. This latter is the coagulating compound and produces an aggregation of the suspended particles into flocculent masses, which settle out to a greater or less degree. In those purification plants where filtration follows the sedimentation of the coagulated matter, a certain proportion of this flocculent material is carried over on to the sand beds of the filters to form the mat which renders possible the rapid filtration of the water.

If instead of sulphate of aluminum, sulphate of iron (copperas) is added to a turbid water containing bicarbonates of lime and magnesia in solution, a somewhat different series of reactions take place. The sulphuric acid associated with the iron forms soluble sulphates with the lime and magnesia as in the preceding case. The iron reacts with the carbonic acid of the carbonates to form a rather soluble bicarbonate of iron. The iron in both this compound and the applied copperas is in the so-called ferrous condition, that is, in a state where it is combined with less oxygen than in the ferric condition or more highly oxidized form. There is a strong tendency for ferrous compounds to become oxidized. The oxygen to produce this change exists in the air dissolved in the water. In consequence of this tendency, the bicarbonate of iron gradually oxidizes, and at the same time decomposes into a ferric hydroxide and carbon dioxide. The latter remains in solution and the former precipitates. It is this insoluble, gelatinous ferric hydroxide which is the coagulating compound desired. It has similar physical properties to the aluminum hydroxide obtained from alum, and is generally regarded as equally effective as the alum compound for coagulating purposes.

The chief objection to using sulphate of iron in the manner just described lies in the slow speed of the reactions which have been explained, due largely to the solubility of the product of the first reaction, namely, ferrous bicarbonate. The limited dissociation of the latter compound and its slight hydrolysis, causes the slow production of only very small quantities of ferrous hydroxide. The conversion of this rather soluble ferrous hydroxide to the insoluble ferric hydroxide, which is the compound aimed to be produced, is therefore, only gradually effected. Hence a water treated with copperas tends to hold the iron in solution so long that its final elimination by sedimentation or by subsequent filtration, if this latter process is used in addition to sedimentation, becomes difficult.

The obvious remedy for rendering the ferrous bicarbonate insoluble and for more rapidly converting it into the insoluble ferric hydroxide, is to take away that portion of the carbonic acid which assists in holding the iron in solution. This can be done by adding caustic lime (or in fact any caustic alkali), which removes a portion of the carbonic acid and causes the reactions to proceed much more rapidly and with far less tendency to reversibility.

The quantity of lime which must be used to effect this result varies with the character of the water being treated. Generally speaking, the greater the temporary hardness of the water, the more lime is required. The actual effect, therefore, is not only to remove the carbonic acid which holds the iron in solution, but that also which keeps the calcium and magnesium in solution. A reduction of the temporary hardness results, or, in other words, the principles involved in the old Porter-Clark process for softening water are utilized. However, this statement only holds good for relatively hard waters, since with low temporary hardness the introduction of caustic lime may actually produce an increase in the total carbonates in solution, although it always reduces the so-called half-bound carbonic acid, which after all is the object sought in this method of coagulation.

If, as in some places, caustic lime is added with the avowed object of introducing a slight excess of this chemical, then not only are the bicarbonates of lime and magnesia reduced, but the magnesium salts are further acted upon with the consequent formation of magnesium hydroxide. This compound is insoluble and has some coagulating properties. The chief effect of the addition of lime in such large amount, however, is to precipitate more completely the salts of lime and magnesia and thereby produce a softer water. This phase of the process is carried to such an extent in some plans as to quite overshadow the coagulation features. It may be added also that it brings to the front a number of problems which are by no means chargeable to the lime and iron process, and which should be carefully distinguished from those resulting from the use of these chemicals for coagulating purposes only.

The iron and lime method for the coagulation of turbid waters owes its development in a large measure to the study of a patented process known as the Jewell Sulphur and Iron Process, which was formerly used in a number of plants in the Middle West with varying degrees of success. The process, as is well known, utilized the acid solution produced by the absorption in water of the fumes of burning sulphur, to dissolve the scrap iron added to it. The weak iron solution thus formed was applied with caustic lime to the water to be treated. The process successfully demonstrated that iron salts could be used for coagulating purposes with the assistance of lime, and that a fairly good quality of water resulted after filtration. It also appeared that the cost of the chemicals would be less than if sulphate of aluminum was used. It was quite apparent, however, that if sulphate of iron could be obtained at a low enough cost, it could be advantageously substituted, in preparing solutions, for the weak iron solution produced in the patented process.

The iron and lime process is indebted to still another very old method for coagulating water known as the Anderson process. This process, which is used in a few places in Europe, makes use of the natural carbonic acid content of the water to be treated, to dissolve a small amount of iron from borings and filings. The water passes through a rotating cylinder containing the iron. By subsequent aeration the dissolved iron is oxidized and precipitated as ferric hydroxide, which produces a sufficient coagulation to enable the water to be successfully purified by filtration through sand filters. The process is of limited application, and on account of the power required to rotate the cylinders and the small amount of iron which can be dissolved and made available as a coagulant, could not successfully compete with other processes.

The general applicability of the lime and iron process to water purification is a question which will naturally arise after considering its various features. Its enthusiastic advocates assert that it may be safely and successfully applied to almost any class of water, and its detractors with equal firmness claim there is little good in it. The truth as in most contentions lies somewhere between these extreme statements. A more extended experience with the process will doubtless answer satisfactorily some of the problems which now confront us.

With colored waters, that is those containing vegetable coloring matter, the applicability of the process is still in some doubt. The well-known tendency for iron salts to form complex soluble compounds with organic matter, which are difficult to decompose and precipitate, appears to be the problem which must first be solved. It will probably require more or less experimental work before we can learn what are the limitations of the process in handling this class of waters.

The use of the process in very soft waters offers some difficulties in the proper balancing of the lime and iron applied without introducing an excess of one or the other chemical. In such cases the alkalinity of the water is likely to be so low as to afford a very narrow margin within which the application of the caustic lime may be applied. Still with skillful handling this trouble ought not to be very serious, especially if the treatment of the water is carefully controlled by chemical tests. In the case of very hard waters the coagulation features of the process are, as noted above, likely to become secondary to the softening of the water. As previously explained, it does not appear absolutely necessary that this should be the direction the process should take, but there is a strong tendency for it to do so because of the desire to effect as much softening as possible. Herein lies the difficulty, for with increased amounts of lime, increased quantities of calcium and magnesium compounds are formed, some of which are slow in precipitating. This is true particularly of the calcium carbonate, which is likely to permeate and precipitate in the sand beds of the filters (where such are used), increasing the size of the sand grains and incrusting the strainer system. These so-called "after deposits" are commonly obtained in all purification plants where softening is an integral part of the process and are by no means peculiar to the

*A paper read at the annual meeting of the Central State Water-Works Association, September, 1906.

†Chemist of the Cincinnati Water Commission.

iron and lime process. They can be largely avoided by an ample period of sedimentation prior to filtration, but for obvious reasons this latter course is not always possible.

An objection which is frequently raised against the process, is that two chemicals are necessary instead of one, as in the case of sulphate of aluminum. The lime whether prepared as a milk of lime or as a lime water is not easily handled or applied. The low solubility of lime in water makes a strong solution impossible, and if lime water is used large volumes of the solution are necessary. If a milk of lime is used, the accuracy of the application is impaired, and the emulsion has a number of objectionable features. The use of hydrated lime applied as a dry powder has not yet been satisfactorily worked out. It is unfortunate that the price of caustic soda bars its use in water purification. Its employment in this process would at once solve a number of difficult problems.

The iron sulphate is very soluble in water and offers no more difficulty in the preparation and application of solutions than does sulphate of aluminum. Its tendency to become oxidized may be largely obviated by properly covered tanks, and only sufficient agitation to insure a uniform solution.

Some of the disadvantages which this process offers having been noted, let us turn to a few of the advantages which it possesses. In the first place it should be clearly kept in mind that the use of iron and lime has passed beyond the experimental stage, and that the process is in successful operation in quite a number of purification plants at the present time. Its most successful application has been to the turbid waters of the Middle West, and it is in this field that it is likely to be most largely adopted.

The chief physical advantage which the use of this process offers is in the rapid sedimentation produced in turbid waters. To those who have not seen the action of these coagulants the quickness with which a water is clarified comes with a good deal of surprise. The coagulum appears to be of a greater specific gravity than that produced with aluminum sulphate. It aggregates in rather small masses, which, however, settle promptly even in a fairly rapid current. The significance of this property of these coagulants is far-reaching. It has been a well-established fact among engineers for a number of years that the preliminary settling of turbid waters in order to remove as much of the sediment as possible before applying the sulphate of aluminum, is, in most cases, economical. Without plain sedimentation, the increased cost of the chemical required to treat the water and the increased volume of wash water needed, if filters were used, more than offset the interest charges on the capital invested in the construction of preliminary settling basins.

If iron and lime are used as coagulants, plain sedimentation may in most cases be eliminated, and relatively small coagulation basins can be made to care for waters carrying extremely large amount of sediment. For small plants drawing directly from a supply liable to sudden fluctuations in turbidity, this ability to handle the water easily without large preliminary settling basins and without excessive amounts of chemicals, is of the greatest importance. Another important feature of this property of these coagulants, when they are used in connection with filtration plants, lies in the diminished amount of sediment thrown upon the filters. The clarification of the water takes place in the coagulation basins, and only enough coagulum need be carried over onto the sand bed of the filters to form a sufficient mat to properly and effectively purify the water. In other words, by increasing the length of time between washings of the filters, the total output of the plant is increased and the proportion of pure water for washing is thereby reduced. The bulk of the work of the purification plant consequently falls upon the coagulation basins, which are less complicated and easier and cheaper to operate than the filters.

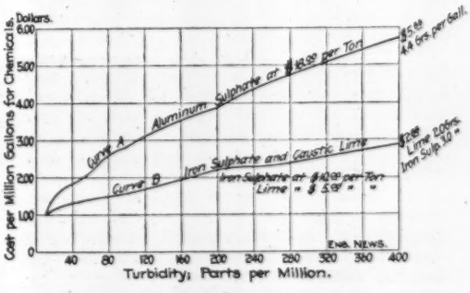
The diminished cost of purification for chemicals where iron and lime are used in place of sulphate of aluminum, is in most cases quite marked. The difference in cost in favor of the lime and iron process is greater the larger the amount of sediment which it is necessary to remove. The less the sediment the less this difference becomes. Local conditions are so variable that any general statement as to the amount of this decreased cost in favor of this process would be misleading. But as an illustration the following table has been compiled from data and from estimates as to the amounts of aluminum sulphate and of sulphate of iron and caustic lime required for the successful purification of subsided Ohio River water at Cincinnati. The estimated amounts of aluminum sulphate were taken from data obtained during the experiments conducted by this city in 1898 and 1899. The estimated amounts of iron and lime required have been derived from more or less experience in observing the effect of varying quantities of these chemicals when applied to Ohio River water and from laboratory experiments:

Estimated Amounts of Sulphate of Aluminum, and of Sulphate of Iron and Caustic Lime Required for Treating Settled Ohio River Water, together with Cost for Chemicals per Million Gallons of Water.

Turbidity parts per 1,000,000	Sulphate of Alumina		Sulp. of Iron and Caustic Lime		
	Grains per Gallon	Cost per 1,000,000 Gals.	Iron, Grains	Lime, Grains	Cost per 1,000,000 Gals.
10	0.75	$0.97	1.00	0.75	$0.90
25	1.25	1.61	1.25	0.90	1.22
50	1.50	1.94	1.40	1.00	1.36
75	1.95	2.51	1.50	1.10	1.47
100	2.20	2.83	1.60	1.20	1.57
125	2.45	3.15	1.75	1.30	1.72
150	2.65	3.41	1.90	1.40	1.86
175	2.85	3.66	2.10	1.50	2.04
200	3.00	3.86	2.25	1.70	2.22
300	3.80	4.89	2.50	1.90	2.47
400	4.40	5.66	3.00	2.00	2.86

Note.—Estimates of cost are based upon sulphate of alumina at $18.00 per ton, sulphate of iron at $10.00 per ton, and caustic lime at $5.00 per ton.

The results given in the table for the cost of treatment have been plotted as curves and illustrate graphically the variation in the cost of chemicals for these two methods. The amounts of iron and lime given for treating the various classes of water are probably higher than will actually be required. The estimated yearly average amount of aluminum sulphate needed for treating the water after plain subsidence is 1.6 grains per gallon, which with this chemical at $18.00 per ton gives an average cost of $2.06 per million gallons. Assuming the average turbidity of the settled water is 60 parts per million, which is probably too low, the estimated amounts of sulphate of iron and caustic lime required would be 1.50 grains per gallon for the former and 1.0 grain for the latter. With the iron at $10.00 per ton and the lime at $5.00 per ton, the average cost of treatment per million gallons would be $1.44. This is $0.62 per million gallons less than for the cost of the aluminum sulphate, or a diminished cost of 30%. With waters having a turbidity of only



Curves Showing Estimated Cost of Chemicals for Treating One Million Gallons of Ohio River Water at Cincinnati, Ohio; After Plain Subsidence.

10 or 15 parts per million there is no practical difference in the cost for chemicals between these two processes; but with high turbidities the increased cost for aluminum sulphate becomes very marked. In the table given above the difference in favor of the iron and lime is 49%, or nearly one-half that of the aluminum sulphate for a turbidity of 400 parts per million. Even greater differences will probably be found in those cases where the water has not received preliminary subsidence.

The use of sulphate of copper in connection with the iron-lime process has many advantageous features. Copper sulphate may be thus used in comparatively small quantities. I attribute the successful sterilization effect of small amounts of copper sulphate on effluents as largely the result of the precipitation of the copper sulphate as carbonate or hydrate of copper upon the sand beds of the filters. It is a case of contact. All the water must pass through the sand beds of the filters and must come into the zone where the hydrate of copper and basic carbonate exerts a sterilizing action. This seems to me to be the only explanation of the sterilizing effect of small quantities of sulphate of copper in connection with filtration plants.

FLAT ALUMINUM BARS are used, instead of cable, for conductors between the plant of the Pittsburg Reduction Co., at Massena, N. Y., and the power-house of the St. Lawrence River Power Co. These conductors are about 1,500 ft. long and carry 17,600 amperes, direct current, under a pressure of 500 volts. The bars are carried by a double pole line, connected by cross timbers on which the bare aluminum bars rest, there being no other insulation. Up to the present time no trouble has developed from this line construction; the wood directly beneath the conductors shows no signs of charring.

SULPHATE OF IRON AND CAUSTIC LIME AS A COAGULANT IN WATER SEDIMENTATION.*

By W. A. Patton.†

I was requested to prepare a paper on sulphate of iron as a coagulant in water filtration. Having had some experience in the use of sulphate of iron, I consented to give the association the benefit of the same, but my experience is in the sedimentation of water instead of filtration.

The plant I operate supplies the cities of Ashland and Catlettsburg, Ky., and Kenova, W. Va.; there are about 16,000 persons on the water line; the pumping station and reservoirs are located at Catlettsburg, Ky., and we take the water from the Big Sandy River, about one mile above the junction of the Ohio and Big Sandy Rivers. While the taking of our water from the Big Sandy River relieves us of the sewage pollution of the Ohio River, yet as far as turbidity is concerned, we must be classed as one of the Ohio River valley systems, and it was to overcome this objection that we equipped our plant for the use of sulphate of iron.

We pump about 2,000,000 gallons of water a day to our reservoirs—four in number—in which we carry from six to eight days' supply. The water is pumped into the bottom of one end of pool No. 4, which we term our settling basin; it is then drawn from the surface of pool No. 4, at the other end (1,000 ft. distance), through a pipe into the bottom of pool No. 3, which we term our middle pool, or second settling basin; from the opposite end of pool No. 3 (1,000 ft. distance) the water is drawn from the surface over a waterfall (in order to aerate it) to the third pool, which we term No. 2—which has a connection in the bottom with our pipe system. Our pool No. 1 is a small pool holding only 1,500,000 gals. of water, it being the first one constructed by us and is now used for what it is worth as extra storage only.

In designing our reservoir system we expected the natural sedimentation and aeration to give us satisfactory results, but in this we were disappointed. We then began investigating water purification. After investigating the various processes for purifying water, as best we could, with the means at our command, we preferred the lime and iron process because in the first place it does away with the necessity of a filter plant. Our objections to a filter plant are: First, the liability of the filter bed becoming contaminated with objectionable bacteria, whereby a certain portion of the bed, in which the washing tubes may become clogged and refuse to act, becomes a breeder of germs instead of a preventive of them. My second objection is the continuous expense of operating the filters. My third objection is the fact that filtered water has the life taken out of it by the removal of the carbonic acid gas, thereby imparting to it a flat taste. I have not investigated the purification of water by electricity, and therefore can give no judgment on this subject. I object to alum as a coagulant on account of the detrimental effect it has on the digestive organs. In this I am fully aware that the advocates of the system state that the alum injected into the water is entirely removed and that proof of the absence is backed up by chemical analysis which shows the filtered water to be free from alum; but it must be remembered that when the chemical analysis is made the plant is new and being run by an expert who is there for the purpose of proving the correctness of his statement only; that but few plants can afford the luxury of the continuous service of an expert chemist; that even when an expert chemist does run a plant continuously, that under the varying conditions, among which may be mentioned the deviation in the pump discharge, the variation in the condition of the water from day to day, the difference in the strength of commercial chemicals, etc., that the filtrate is not continuously free from alum, and in the absence of an expert chemist, is much worse.

As to the use of sulphate of iron and oxide of lime, I can see no objection to the use of them. The quantities used are from a fraction of a grain to two grains of each to a gallon of water; and these are precipitated in the settling basin so that neither goes into the mains. Should there be ten times that amount of each added and all of it go into the mains, no harm would result from the use of the water for family purposes, as many spring waters which are drunk extensively contain more than ten times the quantities of lime and iron that are used.

The sulphate of iron and the oxide of lime are both soluble in water; they are dissolved separately and are injected into the discharge pipe of the pump at different points. In the passage through the pipe to the settling basin chemical action takes place, resulting in the formation of the insoluble oxide of iron and the almost insoluble sulphate of lime, and being insoluble they are deposited by natural sedimentation in the settling basin, thus taking from the water the added chemicals, and in the sedimentation they not only carry down the turbidity, but also the objectionable bacteria.

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*A paper read before the Central States Water-Works Association, September, 1906.

†President, Catlettsburg, Kenova & Ceredo and Ashland Water Companies.

Nearly two years ago we commenced experimenting with lime and iron for the betterment of our service. For the first several months our experiments were extremely crude, but crude as they were, the results were sufficiently satisfactory to assure us we were on the right road to a successful solution of our problem. During this period we made many changes in our method of operation until to-day we believe we can take care of any emergency. The only way to judge any process is from the results, and if the finished product as delivered to our patrons during the past year were to be taken as a basis of judgment in our case, it would not be a recommendation for our system; but in explanation of this we can give good and sufficient reason for our water not being up to the standard, at times. The causes were accidents whose recurrence has now been guarded against and are no argument against the system itself.

During the year we have had weeks and even months of continuous high service while the river was highly turbid, and every day of the year the water delivered to our patrons was far superior to the water we pumped, but as before stated, at times it was not up to the standard.

As the difficulties of a beginner in obtaining experience with this new coagulant may be of interest, I will recite some of our troubles. The entire process being experimental, I first equipped but one pump with which to pump the lime solution, using a reciprocal boiler feed pump with iron plungers. Finding the iron to rapidly attack the plungers, I substituted brass plungers. The brass plungers being no better, we converted the pump into an inside piston-packed using hydraulic packing, which we found to be more satisfactory.

As long as we could deliver the requisite amount of lime solution properly stirred, we had satisfactory results. But when the lime pump would break down, as it did with us on numerous occasions, our brightest hopes for delivering clear water would go glimmering, because the muddy water that we would pump during a short breakdown would be sufficient to highly color a whole reservoir of clear water—perhaps a five or six days' supply—making it necessary to deliver turbid water until the reservoir was emptied. To overcome this trouble we installed a second pump—one of our own construction—and the working of it was so satisfactory that we built another of the same type, and now have the three pumps equipped; one of which does the work and the other two are held in readiness for any emergency.

Our next trouble was in keeping the lime solution properly stirred. If it is not kept continuously in a creamy condition, the treatment of the water will be without good results. To accomplish this we tried several devices, each of which would accomplish satisfactory results during the experimental stage, but when put into continuous practice we would find time and again that turbid water in our reservoir could be traced to our lime solution. To overcome this we installed a regular steamboat wheel in each of our lime tanks. The wheel is 6 ft. in diameter and the same length as the tank and reaches to within 6 ins. of the bottom. Upon the shaft of the wheel there is a sprocket chain connecting it with the countershaft on top of the tank, which shaft is driven by a belt connected with the engine. This device we have found to be very satisfactory as the solution in the tanks is kept continuously in a creamy condition and all of the soluble portion of the lime is pumped from the tank.

Our equipment for the use of the chemica's consists of two concrete tanks, each 12 ft. square and 10 ft. deep for the lime solution, with a concrete mixing tank above, 5 × 8 ft. square and 3 ft. deep. The iron solution is contained in two concrete tanks, each 10 ft. square and 10 ft. deep, with a mixing tank on top, as for the lime solution.

In practice we fill each tank to a depth of 8 ft. In this 8 ft. of water 200 lbs. of chemicals are dissolved; the chemicals being placed in the mixing tank and water passed over them, which is decanted to the storage tank until the required depth is obtained. Then to obtain one grain per gallon we pump 6 ins. from the tank per hour while running our water pump at the rate of 84,000 gallons per hour. To be exact this would require 192 lbs. of chemicals to each batch, but as lime comes in 200-lb. barrels and copperas in 200-lb. sacks, we consider one barrel of lime and one sack of iron sufficiently near for all practical purposes for each batch. To increase or decrease the quantity of chemicals to the gallon we simply increase or decrease the number of inches taken from the tanks.

Our lime solution is pumped through a 2-in. pipe into the discharge pipe of our large pump, while the iron solution is run by gravity from the iron tank to the suction pipe of the large pump. We have been using the solutions for almost two years, and the discharge pipe from the pumps to the reservoirs (4,000 ft. of 14-in. pipe) is free from any incrustation. About 4 ft. from the end of our discharge pipe we built three baffles the depth of the settling basin and 2 ft. apart through which the water has to pass in order to impart to it a whirling motion, and while there is no deposit in the discharge pipe and but little between the baffles the heavy deposit is just beyond the baffles, this deposit having reached the depth of 7 ft. in two years.

The benefit of this treatment can be appreciated when it is known that from a little less than two years' pumping we removed 2,000 tons of sediment from our settling basin (pool No. 4). About one-third of the year our water is clear in the river. Therefore, in 250 days we pumped 1,000 tons of sediment, or an average of four tons a day, which, at two million gallons of water a day, will show a deposit of 28 grains of sediment from each gallon of water.

I have made numerous tests to see if the alkalinity of our water was increased by the use of the lime, using the stearate of soda or soap solution test in a burette, and find the increase to be scarcely perceptible. The increase, when any, only amounts to 7 parts per 1,000,000. I have not had the water examined from a bacteriological standpoint, but the cold fact remains that in 1905, when typhoid fever was epidemic throughout the Big Sandy Valley, from which we pump our supply, and the mortality running unusually high, there was scarcely a case of typhoid fever among the 16,000 persons on our water line but what could be traced directly to an origin in the country.

ANNUAL CONVENTION OF THE CENTRAL STATES WATER-WORKS ASSOCIATION.

The tenth annual convention of the Central States Water-Works Association was held at Cincinnati, O., Sept. 25 to 27. About 200 members and guests were present. Although the convention was held in an Ohio city, a number of municipalities of that state were not represented by delegates, due to the legal interpretation of Ohio Code, which does not permit the expense of delegates to conventions being borne by a municipality.

At the single session held on Tuesday the usual addresses of welcome were delivered, besides which little was done. The report of the treasurer showed a cash balance.

The Wednesday evening session opened with a detailed description, by Mr. Ward Baldwin, Consulting Engineer of Cincinnati, of the performance of the two turbine generator sets installed in the tannery of the American Oak & Leather Co. of Cincinnati, O. Each unit consists of a 300-HP. De Laval steam turbine direct-connected to two 100-KW. alternators. The most interesting facts brought out by Mr. Baldwin were, that about 42 HP. were consumed in running either unit light (without load on the generator), and that the vacuum and the cooling of water obtained by the use of a cooling tower is practically the same the year around, no matter whether the weather is warm or cool. The average pounds of steam per KW. hour for unit No. 1 was 25.5, and for unit No. 2, 26.1; the average pounds of steam per E. HP. hour for unit No. 1 was 19.0, for unit No. 2, 19.5, while the average pounds of steam per B. HP. hour for unit No. 1 equaled 15.3 and for unit No. 2, 16. The discussion, which followed, brought out the fact that the cost of turbines and generators for this plant cost about $30 per HP., while the cost of the complete installation was about $50 per HP.

Two papers on the new water-works of Cincinnati were read: one by Mr. G. H. Benzenberg, Acting Chief Engineer, gave a general description of old and new works, and one by Mr. E. G. Manahan, Assistant Engineer in charge of filtration, described the purification works in some detail. The new works consist of an intake on the Ohio River some miles above the city, a pumping plant, subsiding reservoirs with a combined capacity of 350,000,000 gals., which will be sufficient to give two or three days consumption, two 10,000,000-gal. and one 2,000,000-gal. coagulating basins, and a mechanical filter plant with a daily capacity of 112,000,000 gals. The mechanical filter plant nearest this in size, now in operation, is that of the East Jersey Water Co., at Little Falls, N. J., and has a capacity of 32,000,000 gals. In washing the mechanical filters, neither mechanically operated rakes nor compressed air will be used, but instead the wash water will be forced through the gravel and sand at about 2½ times the customary rate. This method, the author stated, "has been found by Mr. Ellms, Chemist for the Water Commissioners, who originated the process, to give a more thorough and uniform agitation than has been otherwise accomplished." Sulphate of iron and lime will be used for a coagulant. The suspended matter in the river water during more than half the days of the year ranges from 200 to [illegible]0. The bacteria average "as high as 20,000 per cu. cm. and at times run above 100,000." It is expected that subsidence alone will remove from [illegible] to 80% of the suspended matter and an average of 50% of the bacteria, while of the remaining suspended matter and bacteria 50 to 90% will be removed in the coagulating basins. Filtration is expected, will complete the removal of the suspended matter and leave only about [illegible] of the original bacteria. A 20,000,000-gal. clear water basin is now nearly completed. This will not be covered for the present, but the design provides for roofing it if found necessary. One of the sedimentation basins has been completed.

In the construction of the filters and the various buildings concrete is being extensively used. The 28 filter units will be "monolithic boxes of reinforced concrete 50 × 32 ft." in plan by about 11 ft. deep. Electric power will be used for operating all the filter pumps, stirring machinery, and all valves more than 16 ins. in diameter. There will be a total of 170 electrically-operated valves, of which 11 will be 84 ins. in diameter and another 11 will be 60 ins. in diameter.

Two papers on the use of sulphate of iron and lime as a coagulant were presented at the convention and are reprinted elsewhere in this issue. One of these was by Mr. J. W. Ellms, Chemist of the new Cincinnati water-works, and was a valuable general discussion of the subject, with special reference to information gained by tests at Cincinnati. The other paper, read by Mr. W. A. Patton, related to experience at a plant supplying the Catletisburg, Ky., and nearby towns.

A paper on water waste and means for its prevention at Akron, O., was read by Mr. L. M. Latta, General Manager of the Akron Water-Works Co. The net result of the combined use of water meters and inspectors has been a material increase in income, but a failure thus far "to reduce appreciably the consumption per head," which still remains about 250 gals. per head of population. The number of meters set has not been large. The metered water sold during 1905 produced a rate 61% greater than the unit rate for water sold on the fixture basis.

In the discussion following this paper, attention was called to the large amount of apparent water waste due to inefficient condition of pumping plants. Mr. Jerry O'Shaughnessy stated that by overhauling pumps and inspecting services he had reduced an indicated pumpage of 21,000,000 to 14,000,000 gals. per day, although meanwhile some 6,000 service taps had been made. Mr. George Hornung, formerly superintendent of the water-works at Newport, Ky., stated that by installing a Venturi meter he found a lost pump action of 45 to 50%.

An unusual thing for conventions was done on Thursday afternoon when in place of the proposed excursion it was decided to hold a session. At this session a paper on the general subject of filtration, illustrated by lantern slides, was read by Mr. F. P. Leopold, of the Pittsburg Manufacturing Co., Pittsburg, Pa.

Wheeling, W. Va., was chosen for the place of the next meeting. The following are the principal officers elected for 1906-7: President, Thomas R. Cook, Toledo, O.; Vice-President at large, John Langan, Tipton, Ind.; Secretary, W. A. Veach, Newark, O.; Treasurer, A. W. Inman, Massillon, O.

LARGE ELECTRIC MOTORS FOR RAIL MILL driving have been ordered by the Indiana Steel Co., of Chicago, Ill., a subsidiary company of the U. S. Steel Corporation. These motors will be used in the rail mill of the great new steel plant at Gary, Ind. Among them are two 2,000 HP. motors operating at 214 r. p. m.; one 2,000 HP. motor operating at 88 r. p. m.; and three 6,000 HP. motors operating at 88, 83.3, and 75 r. p. m., respectively. The three 2,000-HP. motors are rated at 3,000 HP. each for 1 hr. with a temperature rise of 60° C., and the three 6,000-HP. motors are rated at 9,000 HP. each for the same length of time and temperature rise. Two of the 2,000

HP. motors will be used to drive the blooming rolls, one 6,000 HP. motor will drive the finishing mills, second edger and leader passes, another 6,000-HP. motor will drive the high blooming mills, and the third will drive the dummy and first edger. The remaining 2,000 HP. motor will operate the stand of rolls in which the finishing pass is given. This electric equipment is to be supplied by the General Electric Co., of Schenectady, N. Y.

A STEAM MOTOR CAR for railway service has just been completed by the St. Louis Car Co., after designs by Messrs. Geo. J. Kobusch, President of the company, and W. G. Wagenhals. The car measures 82 ft. 6 ins. over all and has the very great weight of 178,560 lbs., of which 115,600 lbs. is on the four driving wheels at one end. The water tube boiler used is of torpedo-boat type and has 1,215 sq. ft. of heating surface and 43.5 sq. ft. of grate area. It is fired with crude oil, and tanks holding 1,000 gallons of oil are carried on the car. The steam pressure is 250 lbs. per sq. in. The engine is of 275 HP. and has two cylinders, 11 × 12 ins. A pinion on the crank shaft drives a gear wheel on the driving axle, and a speed reduction is obtained in this way so that a tractive effort of 8,000 lbs. is secured. The second pair of driving wheels is driven by parallel rods from the main axle. The car is to be run to various railway centers for exhibition and will later be put in service on the Missouri Pacific Ry. For the above particulars we are indebted to "The Railway and Engineering Review" of Sept. 29.

A COAST LINE RAILROAD between San Francisco, Cal., and Portland, Ore., is to be built by the Southern Pacific Co. The route selected is from Tiburon, Cal., to Sherwood, Cal., to Eureka, Cal., to Coos Bay, Ore., to Corvallis, Ore., to Portland. The road from Eureka to Tiburon will be used jointly by the Southern Pacific and the Atchison, Topeka & Santa Fe Rys. to enter San Francisco. The Southern Pacific already has a road from Portland to Corvallis, which road it is now extending to Coos Bay, where it will connect with the Coos Bay, Roseburg & Eastern R. R., a road extending 25 miles south of Coos Bay to Myrtle Point. This road is also owned by the Southern Pacific Co. and will be extended through the Rogue River Mountains to Luffenholtz, Cal., where it will join another short line reaching to Eureka. From Eureka to Camp Five the Santa Fe line will be used. Camp Five and Sherwood will be connected by a line which is being jointly constructed by the Southern Pacific and Santa Fe roads. The track of the California Northwestern Ry. will be used from Sherwood to Tiburon. A holding company will be organized by the Southern Pacific and Sante Fe companies to own all the trackage between Eureka and San Francisco, which will include the California Northwestern Ry. (S. P.), the North Shore R. R. (Santa Fe) and the new line from Camp Five to Sherwood. The object of this holding company is the harmonious joint usage of these tracks by the two above-named railways.

STRINGENT RULES FOR THE HANDLING OF EXplosives have been adopted by the Pennsylvania Railroad. According to the new rules only cars in good condition and of at least 60,000 lbs. capacity may be used to carry black powder, high explosives, smokeless powder, fulminates and great-gun ammunition. Such cars may not, moreover, be placed in a train nearer to each other than five car lengths, and if possible must not be within 15 cars of the engine and 10 cars of the caboose. No cars loaded with explosives will be allowed in a mixed train, that is, in a train carrying both passengers and freight. The cars at either end of the one loaded with explosives must not be loaded with oil, lumber or other inflammable material, nor iron bars, pipe or other articles likely to break through the end of the car from rough handling. Before a car is loaded with an explosive it must be examined by an agent or inspector, who will issue a "Certificate of Inspection of Car Containing Explosives," which certificate must also be signed by the shipper if he loads the car. These cars must then be marked on both ends and both sides in large letters, "Explosives, Handle Carefully; Keep Fire Away," while on both sides there must be attached certificates of inspection. Cars containing explosives must, moreover, be inspected by the trainmen each time the train stops.

THE LARGEST BATTLESHIP EVER LAUNCHED for the American Navy, the "Connecticut," was placed in commission at the New York Navy Yard, Sept. 29. She was built by the U. S. Government at the New York Navy Yard and was launched Sept. 29, 1904 (Eng. News, Oct. 20, 1904, p. 366). The "Connecticut" has a displacement of 16,000 tons, and carries an armament of four 12-in., eight 8-in., twelve 7-in., twenty 3-in., twelve 3-pounders and eight 1-pounder guns, besides guns of small caliber. This is a sister ship to the "Louisiana," which was built by a private concern, and has been in commission several months. Nevertheless, the "Connecticut" is said to be nearer completed than the "Louisiana."

AN OPEN SWITCH was the cause of a bad wreck Sept. 26 on the Wabash R. R. at Caltin, Ill. A fast passenger train known as the "Buffalo Mail," running at 60 miles per hour, struck the open switch and crashed into a freight train, which stood on the siding. The wreckage immediately took fire, and all the cars of the passenger train, except the diner, were destroyed. Six persons were killed and forty others injured, five fatally. The switch had been left open by the freight train crew.

A BAD ACCIDENT occurred on the Pennsylvania Railroad near Eddington, Pa., Sept. 29, when the brakes on a New York-Philadelphia express train failed to work, causing it to crash into a stalled Long Branch express. Three cars of the Long Branch train were telescoped, and three persons killed and forty others injured, some fatally. Signals were set against the New York express but the engineer was unable to stop the train; according to press dispatches an investigation after the wreck showed that the "angle cock" on the third car was closed so that the brakes on the remaining seven cars were useless. The Long Branch express had been stalled by a faulty air-brake.

A SEVERE HURRICANE swept over the southern tier of States Wednesday evening, Sept. 26, lasting some 48 hours. All Gulf towns suffered considerable property loss although Pensacola, Fla., and Mobile, Ala., suffered to the greater extent. The latest press reports place the number of deaths at Pensacola at 24 and the estimated property loss in that town and vicinity at $4,000,000, while 120 are reported dead at Mobile, and the property loss is placed at $8,000,000. The U. S. Navy Yard at Pensacola suffered to the extent of $2,000,000, three gun-boats, the "Machias," "Gloucester" and "Waban," being sunk. At Mobile the small revenue cutter "Alert" was rammed during the storm by an unknown vessel and sunk. Nearly all docks at Mobile and Pensacola were destroyed, and many vessels were driven high on the beach and wrecked. Besides the damage done in the towns much damage is reported from the country, crops and fruits being destroyed. The railroads were also heavy losers, much trackage and dockage being destroyed.

THE LARGEST GAS ENGINE DRIVEN ELECTRIC plant thus far noted is to be installed for the Milwaukee Northern Ry., a new interurban line that will extend from Port Washington, Wis., to Milwaukee. Three horizontal twin tandem gas engines, each with a rated capacity of 1,500 HP. will be direct connected to three 1,000 KW., 3-phase, 25-cycle, alternators. These generating units will be installed in the main power-house at Port Washington on the harbor front, where coal can be unloaded conveniently to the gas producer plant. The six gas engines and alternators mentioned, together with the gas-driven exciter sets and equipments for the eight substations to be used, are of Allis-Chalmers manufacture.

THE ELECTRIC TRAINS IN THE SIMPLON TUNnel have been running regularly and satisfactorily since August 1. The only steam-operated trains are the through trains de luxe, which run three times a week, and a train running daily through the tunnel between Iselle and Domo Dossola. From 18 to 28 minutes are required by the trains to pass through the tunnel which is about 12 miles long. The shortest time is made by the southbound electric trains, and the longest time by the northbound steam expresses. Two additional electric locomotives of 1,000 HP. each have been ordered from Messrs. Brown, Boveri & Co., who supplied those now in use. At the present time 15 electric trains pass through the tunnel daily. Considerable trouble has been experienced from the accummulation of soot on the insulators of the overhead conductors, and the effect of the dampness of the atmosphere on the motors. The first mentioned trouble is alleviated by frequently cleaning the insulators between working periods, and the last mentioned trouble by completely enclosing the motors and depending entirely upon the internal ventilation.

THE LARGEST CARGO thus far carried by a single vessel on the Great Lakes was placed on the steamship "Henry W. Rogers" at Escanaba, Mich., Sept. 18; the cargo amounted to 13,333 gross or 15,081 net tons of iron ore. The vessel draws 21½ ft. of water. Two Brown hoists on the Northwestern electric dock also broke all records in unloading coal from a lake freighter, by taking out 4,200 tons of hard coal in 10 hrs.

TESTS OF SUBMARINE SIGNALS, carried on during the months of June and July by the United States Light House Board, proved of such value to navigation that the Board has arranged to take over and operate the signals on the following lightships: Cape Elizabeth, Boston Lightship, Pollock Rip Shoals Lightship, Nantucket Shoals Lightship, Vineyard Sound Lightship, Brenton Reef Lightship, Cornfield Point Lightship, Fire Island Lightship, Sandy Hook Lightship, Overfalls Lightship, Fenwick Island, Five-Fathom Bank, Winter Quarter Shoal, Cape Charles, Tail of the Horseshoe, Diamond Shoal. The following points are also now equipped with submarine bells: Red Island, River St. Lawrence; White Island, River St. Lawrence; Prince Shoals, River St. Lawrence (mouth of Saguenay); Anticosti, Gulf of St. Lawrence; Chebucto Head, southern entrance to Halifax Harbor; Lurcher Shoals Lightship, Yarmouth, N. S.; Kiel Lightship, Germany; Elbe Lightship, Hamburg; Outer-Weser Lightship, Bremen, Aussenjade Lightship, Bremerhaven; Northwest Lightship, near Liverpool; Cherbourg, France (North German Lloyd Tender). This system of signalling (Eng. News, July 12, 1906, p. 38), which rings the number of the light ship at stated intervals, has, according to the reports made by masters of vessels equipped with the receiving apparatus, given them information regarding their course long before the foghorns were heard. The distance at which the submarine bell was heard varied from 1¾ to 15 miles, depending on the condition of the weather, that is, when the weather was thick, it was heard farther, since the navigating officers were more alert.

THE SAFETY-APPLIANCE LAW is to be more rigidly enforced in future. Attorney-General Moody has ordered suits brought against a large number of railway companies on account of violations. The total number of cases to be brought is 181. Of these 51 are against the Delaware & Hudson Co., 35 against the Wabash lines and 15 against the Rock Island. The statutory penalty for each violation is $100.

THE WATER SUPPLY OF LOUISVILLE, KY., according to the Committee on Fire Prevention of the National Board of Fire Underwriters (135 William St., New York), is fairly ample in the congested value district but is limited in other sections by faults in the distribution system and by low pressure. The report states that no plan of the distribution system has ever been made. The fire department has an inadequate number of companies, but in general it is otherwise efficient. The fire alarm system is unreliable. The building laws "omit practically all the measures necessary to secure the erection of desirable buildings," and their enforcement is "only fair." The conflagration hazard is severe in the congested value district.

THE FOREIGN COMMERCE OF THE UNITED States fir the year ending with August, 1906, exceeded $3,000,000,000. The imports and exports for the month of August, 1906, exceeded those of any preceding August, while the imports for August, for the first time, exceeded $100,000,000. The exports were also larger than for any similar preceding month by about $11,000,000. Meat and dairy products exported showed a large increase, except canned beef, which showed a marked decline. Other articles of export also showed an increase, while the growth of imports was principally in manufacturer's materials and crude products.

A PIPE LINE for conveying petroleum on the Isthmus of Panama, has been completed by the Union Oil Co., of Los Angeles, Cal. The line is 45 miles long and will convey California petroleum, carried to Panama by tank steamers. The daily consumption is expected to amount to 3,000 bbls., as the Panama Railroad and the power and electric plants of the Isthmus will convert their coal furnaces to oil burners.

RAILROADS IN INDIA have been reported upon by Consul-General W. H. Michael, of Calcutta, in part, as follows:

At the end of April, 1906, the number of miles of railroad in operation in India was 28,617, and the number under construction and sanctioned was 3,297. The number of miles of standard gage, 5 ft. 6 ins., is 15,399; miles of meter gage, 3 ft. 3⅜ ins., 12,098; miles of 2-ft. 6-in. gage, 1,097, and miles of 2-ft. gage, 328. The total outlay on construction, including miscellaneous items, is $396,202,752. The gross earnings of all Indian railways during the calendar year 1905 amounted in round figures to 137,544,000 rupees ($44,564,256), an increase over the previous year of 1904 of 6,699,000 rupees ($2,170,476). The net earnings for the year amounted to 71,742,000 rupees ($23,244,408), which was nearly 6% on the capital outlay. The average rate charged to passengers of all classes was a trifle more than one-fifth of an English penny, or 2.47 pies, or 0.42-ct., and the average distance traveled was 40 miles. [U. S. Consular Reports, Sept. 14, 1906.]

THE VALUE OF THE FRANCHISES or intangible property of the Chicago City Railway Co. and the Union Traction Co. (exclusive of the consolidated system) has been placed at $10,332,228 and $13,825,040, respectively, making a total of $24,157,268. The valuation previously put upon the tangible property of the two companies brings the total valuation up to about $71,500,000. These figures have been arrived at by the railway companies in connection with the proposed purchase of their property by the city. The basis used in fixing the price for

the franchises of the City Railway Company have been stated as follows:

(1) That, taking into account the existing situation, a fair allowance to the company for its intangible rights would be the value of the right of the company to operate its entire system for a term of seven years.

(2) That the gross receipts from the operation of the company's street railways would increase at the rate of 5% in each year over the gross receipts for the preceding year.

(3) That the net profits from the operation of its street railways would amount to 30% of its gross receipts, less interest on the value of the company's tangible property.

A somewhat similar statement has been made in behalf of the other company. It may be explained in conclusion that the rights of the various companies in the streets of Chicago have long been a subject of controversy.

GRADE CROSSINGS AT COLUMBUS, OHIO, between steam and electric or street car lines are being eliminated at an estimated expense of a million dollars. The cost of the work is being distributed, one-half to the steam roads, one-eighth to the street car company and three-eighths to the city.

NOTES FROM ENGINEERING SCHOOLS.

THE STRUCTURAL ENGINEERING SCHOOL of the West Side (New York City) Y. M. C. A.—The school will reopen Oct. 2 with an enlarged curriculum, in order to furnish instruction in general building construction, estimating and drafting. The studies will not be highly technical and are designed for superintendents, foremen, clerks, mechanics and others, who desire such training in order to rise to better positions. The work is divided into two courses, one in "Structural Engineering and Design" and the other in "Structural Drafting and Detailing," and no entrance examinations will be held, the men being assigned to such studies as they are capable of taking up. Further information regarding these courses can be had by addressing the Educational Department of the West Side Y. M. C. A., 318 W. 57th St., New York City.

PERSONALS.

Mr. George Thompson has been appointed Superintendent of Motive Power of the Denver, Northwestern & Pacific Ry., to succeed Mr. A. Struthers, resigned.

Mr. S. W. Brown, Superintendent of the Eastern Division of the Lake Shore & Michigan Southern Ry., has been promoted to Assistant General Superintendent, and is succeeded by Mr. H. M. Tompkins, who has been his assistant.

Mr. Louis Block, formerly head of the Engineering Department of the De La Vergne Machine Co., of New York City, has opened offices at 45 E. 42d St., New York, as consulting engineer. He will give special attention to ice manufacturing and refrigerating plants.

Mr. H. J. Mac Nais, formerly Geographer for the Scarborogh Co. of Boston, Mass. and Indianapolis, Ind., has opened offices in the Marine Bank Building, Buffalo, N. Y., and will specialize on pedagogical maps and charts along the lines of economic geography and physiography.

Mr. H. A. Worcester, General Superintendent of the Lake Shore & Michigan Southern Ry., has been promoted to Assistant General Manager of the Cleveland, Cincinnati, Chicago & St. Louis Ry., to succeed Mr. J. O. Van Winkle, advanced to General Manager. Mr. John J. Bernet has been appointed to succeed Mr. Worcester.

Mr. H. A. Schwanecke, of Marshall, Ill., has been appointed Chief Engineer of the Pittsburgh, Binghamton & Eastern R. R., to succeed Mr. George A. Ricker, who resigned the position of Acting Chief Engineer to resume his private practice at Buffalo, N. Y. Mr. Ricker is, however, retained by the Pittsburgh, Binghamton & Eastern R. R. Co. as Consulting Engineer.

Mr. J. R. Worcester, Consulting Engineer, with offices formerly in the Exchange Bldg., Boston, Mass., has formed a partnership with Mr. E. E. Pettee and Mr. G. H. Brazer, under the firm name of J. R. Worcester & Co., Consulting Engineers, and opened offices at 79 Milk St., Boston. They will give special attention to the design of steel and reinforced concrete structures, and foundations of all kinds.

The following changes have taken place in the personnel of the Reclamation Service: Mr. Jos. E. Bell has been appointed engineering aid and assigned to S. B. Robbins, Great Falls, Mont.; Mr. Wellington P. Hews has been appointed engineering aid and assigned to Boise, Idaho; Mr. Fred O. Stevens has been appointed engineering aid and assigned to J. E. Field, Mitchell, Neb.; Mr. C. K. Francis, cement expert, has resigned from the service.

Mr. W. B. Poland, M. Am. Soc. C. E., formerly Chief Engineer and General Manager of the Alaska Central Ry., has been elected Vice-President and Chief Engineer of the Philippine Railway Co. He will go to Manila to take charge of the construction of railroads building on the Islands of Panay, Negros and Cebu. His address will be 43 Exchange Pl., New York City, and Manila, P. I. Mr. Poland is a graduate of the Massachusetts Institute of Technology, and has at different times been connected with the River and Harbor Work of the United States Government, the Peoria & Eastern Ry., the Cleveland, Cincinnati, Chicago & St. Louis Ry., and the Baltimore & Ohio R. R. In 1901 he became connected with the Alaska Central Ry. as Chief Engineer and General Manager, which position he resigned Sept. 1, 1906.

Obituary.

George F. Hodgeman, President of the Hodgeman Rubber Co. of New York City, died at London, Sept. 28, of heart disease, aged 61 years.

William P. Fodell, Secretary and Treasurer of the Northern Liberties Gas Works of Philadelphia, died at his home in Philadelphia, Pa., Sept. 25.

Alfred S. Brown, formerly Superintendent of the Eastern District of the Western Union Telegraph Co., died at New York City Sept. 25, aged 71 years.

William H. Fenwick died at his home in Bayonne, N. J., Sept. 24, aged 83 years. He was a shipbuilder by trade and aided in the design and construction of the "Monitor" and the cup defender "America."

Louis Schutte, M. Am. Soc. M. E., senior member of the Schutte-Koerting Co., of Philadelphia, Pa., died at his home in that city Sept. 29, aged 65 years. He was a native of Germany but removed to the United States in 1870.

John McDonald, who was connected with the engineering department of the Japanese Government Railways from 1873 to 1901, died in London, England, Sept. 15, at the age of 62 years. He received two decorations from the Japanese Government on account of his services, and in 1891 the British Institution of Civil Engineers awarded the Telford Premium to a paper on "The Vibratory Movements of Locomotives," written jointly by Mr. McDonald and Prof. Milne.

Lieut. Col. J. L. Lusk, of the Corps of Engineers, U. S. A., committed suicide at Fort Hancock, Sept. 26, by cutting his throat. He was 51 years of age. He had been in poor health a large part of the time, since the Spanish-American War, having contracted the typhoid fever in that campaign, which affected his mind, and from which he had never fully recovered. He graduated from West Point in 1878 with honor, and was immediately assigned to the Engineering Corps as Assistant Instructor in practical military engineering and of natural and experimental philosophy, at the Military Academy. Later he was assigned to duty in the Department of Mathematics after a short term of duty in the field. At the outbreak of the Spanish-American War he was sent to Tampa, Fla., in command of Company E of the Engineering Corps. Upon his arrival there he was made Lieutenant Colonel of Engineers, later being assigned to the Second Army Corps as Chief Engineer and sent to Cuba. He was made Lieutenant Colonel in the regular army last June. Since the Spanish War he has been connected with U. S. engineering work at Rock Island, Ill., Engineer in Charge of the Lake Survey at Detroit, Mich., and Assistant to the Chief of Engineers.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 8-9. Annual Meeting at New York City. Secy., S. S. Sadler, 39 South 10th St., Philadelphia, Pa.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 9 to 12. Annual Meeting at Birmingham, Ala. Secy., G. W. Tillson, Municipal Bldg., Brooklyn, N. Y.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 15 to 19. Annual Convention at Columbus, Ohio. Secy., Bernard V. Swenson, 60 Wall St., New York City.

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.
Oct. 16. Annual Meeting at Boston, Mass. Secy., S. F. Patterson, Concord, N. H., c/o Boston & Maine R. R.

THE RAILWAY SIGNAL ASSOCIATION.
Oct. 16-18. Annual Meeting at Washington, D. C. Secy., H. S. Balliet, Grand Central Station, New York City.

AMERICAN GAS INSTITUTE.
Oct. 17-19. First Annual Meeting at Chicago, Ill. Acting Secy., James W. Dunbar, New Albany, Ind.

ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION OF AMERICA.
Nov. 13-15. Annual Meeting at Chicago, Ill. Secy., C. E. Jones, Beardstown, Ill.

AMERICAN MINING CONGRESS.
Nov. 13-17. Annual Meeting at Denver, Colo. Secy., J. F. Callbreath, Jr., Denver, Colo.

THE CONCRETE ASSOCIATION OF NEW YORK.—At a meeting of the association to be held in the Madison Square Garden Concert Hall, 25th St. entrance, Oct. 24, Mr. Richard L. Humphrey, M. Am. Soc. C. E., will deliver a stereoptican lecture on building construction. Mr. Humphrey was sent to San Francisco by the U. S. Geological Survey shortly after the destructive earthquake and fire, and while there obtained some 500 views, which he will use in his lecture.

ILLUMINATING ENGINEERING SOCIETY.—A meeting of the society will be held in the Edison Auditorium, 44 W. 27th St., New York City, Oct. 12, when the membership of New York City and vicinity will be organized as the New York Section of the Society. Two papers on "Data of Indoor Illumination" will be presented, one by Mr. J. E. Woodwell, Inspector of Electric Lighting Plants, U. S. Treasury Department, and the other by Mr. E. C. White, Illuminating Engineer, Winnipeg, Manitoba.

THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—The thirteenth annual convention of the society will be held at Birmingham, Ala., Oct. 9-12. The meetings of the convention will be held in Convention Hall, the third floor of the City Hall, while hotel headquarters will be at Hotel Hillman. Room 23 City Hall will be open Tuesday morning, Oct. 9, at 11 o'clock for registration, the issuing of badges, credentials, etc.

The convention will be opened Tuesday afternoon at 2 o'clock with an address of welcome by Mayor George B. Ward of Birmingham. President of the Society, Mr. Charles C. Brown, will reply, after which the regular order of business will be taken up, including reports of committees, etc. A second session will be held at 8 p. m. for the reading of papers and further reports of committees.

The Wednesday morning session will open with an address on the Birmingham District by Mr. J. W. Bowron, after which the convention will be tendered a drive about town by the Commercial Club and citizens of Birmingham, ending with an old-fashioned Southern barbecue at the water-works station on Shades Mountain.

Business sessions will be held Wednesday and Thursday evenings and Friday morning and afternoon for the reading of papers, etc. Thursday will be given over to an excursion for inspecting the industrial district about the city.

Among the many papers to be read before the convention are the following:

"Yellow Fever and Sanitation," J. N. Hazlehurst; "The Water-Works of Archangel, Russia," Ulrich E. Taubenheim; "Tests of Other Wood Than Yellow Pine for Block Pavements," F. A. Kummer.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The 200th meeting was held Friday, Sept. 28, in the auditorium of the New York Edison Building, 44 West 27th St., New York City. Nearly 200 members were in attendance. The new President, Dr. Samuel Sheldon, occupied the chair and read his inaugural address entitled, "The Work of the Institute." He referred to the removal of the executive offices to the new Engineering Building, which will be ready for occupancy Dec. 1, 1906, and the increased expenditure for carrying on the Institute work that this would entail. He suggested the membership be increased to provide for this extra outlay, and stated that it would be possible with but slight additional expense to care for twice as many members as are enrolled at present. In this connection it may be mentioned that 191 new members were added during the afternoon session. The Building Fund Committee has already succeeded in raising $132,000 of the $180,000 due from the Institute. In accordance with requests from members engaged in telephone work for more papers and discussions on telephony, Dr. Sheldon stated that more attention would be given this subject in the future. Following the President's address a paper entitled "The Effect of Iron in Distorting Alternating-Current Wave Form," by Frederick Bedell and Elbert B. Tuttle, was presented in abstract by Prof. Bedell. The subject of the paper was discussed at length by Mr. C. P. Steinmetz who treated it both from theoretical and practical standpoints. Prof. W. S. Franklin took exception to elaborate theoretical discussions of alternating-current phenomena which have no practical application, and gave it his opinion that no quantities not obtainable on measuring instruments employed in practice, should be taken into consideration. The second paper, entitled "The Current Transformer," by Kenneth L. Curtis, was briefly abstracted by Mr. A. S. McAllister. Mr. L. T. Robinson then gave some interesting matter on current transformers from data obtained in work for the General Electric Co.